THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company

James H. McGraw, Pres.
J. M. Wakeman, 1st Vice-Pres. H. S. Buttenheim, Sec.
A. E. Clifford, 2d Vice-Pres, C. E. Whittlesey, Treas

J. M. Goodell, Editor

MAIN OFFICES:
239 WEST 39TH STREET, NEW YORK.
BRANCH OFFICES:
CHICAGO: Old Colony Building.
PHILADELPHIA: Real Estate Trust Building.
CLEVELAND: Schofield Building.
SAN FRANCISCO: Atlas Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Cuba and Mexico............$3.00 a year
Canada ....$4.50 a year
Foreign subscription.......................$6.00 a year
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGE OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to July, 1906, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1907, by the McGraw Publishing Co.

The circulation of THE ENGINEERING RECORD for 1907 was 763,000 copies, an average of 14,673 copies per week.

Of this issue 15,000 copies are printed.

TABLE OF LEADING ARTICLES.

Safe Stresses in Steel Columns.................. 141
Smokeless Combustion.................. 141
Some Educational Problems.................. 142
The Wood Preserver's Association.................. 143
Preliminary Work on the Los Angeles Aqueduct (Illustrated) 144
The Necessity of Continuity in the Steel Reinforcement of Concrete Structures.................. 147
New York State Water Powers.................. 149
The Roundhouse of the Lehigh & Hudson River Ry. at Warwick, N. Y. (Illustrated).................. 150
Construction of Lock 3, Erie Barge Canal (Illustrated) 151
Hydraulic Sluicing with Jet Elevators.................. 152
A System of Filing Engineering Notes and Records (Illustrated) 153
Mechanical Plant of the Worcester Cold Storage & Warehouse Co. (Illustrated).................. 155
Experiments with Tar and Oil on the Highways of Rhode Island.................. 157
A Reinforced Concrete Cement Stock House (Illustrated) 159
Stresses in Masonry Dams.................. 162
Progress on the Baltimore Sewerage Works (Illustrated) 163
Reinforced Concrete from the Contractor's Standpoint 165
Book Notes.................. 167
Reinforced Concrete in Foundations.................. 167
The Cameron Septic Tank Patent.................. 168
Size of Reinforcement Bars (Illustrated).................. 168
Conservation of Water Power.................. 168

Safe Stresses in Steel Columns.

The investigations and discussions which have been stimulated by the failure of the Quebec Bridge, have started anew the broad question of the carrying capacity of such steel compression members as are commonly employed in bridge construction. This is evidenced by the communications in the correspondence columns of this and other journals and most lately by a paper printed in the "Proceedings" of the American Society of Civil Engineers for January by Mr. J. R. Worcester. In his paper Mr. Worcester reviews in a general way practically all of the older wrought-iron column tests and proposes a new column formula of less simplicity than either the old Gordon form or the later straight line equation. There may be some question whether a new type of formula based upon some arbitrary curve is required so much as a clearer interpretation of the tests already made or to be made in connection with the application of the theory of elastic bending to the ordinary steel column.

It is decidedly unfortunate that engineers should desire to use a column formula at all, for there is no theory or rational formula in existence by which either the elastic or ultimate carrying power of an ordinary bridge column can be computed. It is too often forgotten among those who discuss this general question of columns that Euler's formula, based upon the theory of pure flexure as applied to compression members, is absolutely inapplicable to any columns whatever used in bridges or other structures. It does not include the effect of direct compression and the attempt to provide for that produces the form of Gordon's formula. For the reason just stated, it is irrational to make such a use of Euler's formula. Hence Gordon's form of equation involves all that is irrational in applying Euler's formula to such short columns as are always employed in engineering practice.

It would be far better and simpler in every way to use an accurately constructed diagram showing the results of actual tests of columns for various values of length divided by radius of gyration. An average line drawn through the empirically determined points of such a diagram would show at a glance what the working stress of a column of a given length should be. It was the construction and consideration of such diagrams that led to the straight line formula first proposed and brought out in papers read at the convention of the American Society of Civil Engineers in 1881. This is obviously the simplest formula possible and it is reasonably accurate as a formula for all lengths of columns ordinarily employed in structural work. It has many times been pointed out, nevertheless, since this formula was first proposed, that an accurate diagram would possess more advantages than any possible formula, however simple it might be. The great difficulty now existing is the absence of all but the most meagre tests of full-size steel columns. It is really idle to give much consideration to any new form of formula until we have a sufficient range of tests of steel compression members to show whether the old forms are not sufficient if any formula is to be used or to construct, what is better yet, an empirical mean curve on a diagram of actual tests. The lengths of columns usually employed in engineering structures mostly range from 50 to 120 radii of gyration. Within those limits, the mean empirical curve as shown by the old wrought-iron column tests is essentially a straight line. Although its inclination is small, it is distinctly not a horizontal line. Whether properly designed steel columns would show precisely parallel results can only be determined by the testing machine. Many, if not nearly all, of the older columns failed locally, between the lattice points in the case of latticed columns. With proper spacing members and with suitable proportions of other details, the column should fail as a whole, and that obviously is the end to be attained in the best column design.

Compression members have one physical characteristic developed under test which differentiates them fundamentally from tensile members, as remarked by Mr. Worcester, and that is the fact that their elastic limit at best cannot be much short of their ultimate resistance, and when their spacing details and proportions of various parts are not such as to develop the highest carrying power, the ultimate may coincide with the elastic limit. This has frequently been observed in the case of sudden test failures which take place before any sensible distortion is evidenced. In the best design of columns, therefore, the effort should always be made so to proportion all details as to develop an ultimate load high enough to produce as much distortion as possible before actual failure of the member. With low values of length in terms of radii of gyration, this obviously means relatively heavy lattice bars and strong rivet connections between them and the component parts of the post or column.

Reflection upon this latter observation will show how futile it is to attempt to form any theory for the computation of lattice bar stresses, and consequently any analytical method of design of those bars, although a number of such methods have been put forth. Such methods have in some cases proved to be dangerously delusive. There is no obvious reason why the perfectly straight elements of a column should bend while under any loading, but it is perfectly well known that they will bend out of line under some intensity of compression. This result is probably produced by the unavoidable small imperfections of manufacture or by some unnoticeable inequality of loading, all of which influences are completely indeterminate, and to attempt to represent them by a formula may be dangerously misleading. Similarly, any arbitrary basis of assumed shear to be transferred from one part of a column to another for such computations is certainly likely to be erroneous. Such indeterminate elements of a problem must necessarily be established by test, although some useful inferences may be drawn from the satisfactory action of known latticing in successful work. Enough has been established up to the present time to show clearly that the safe working stress of steel columns depends absolutely upon the lattice bars or other spacing members of steel columns, and that the shorter the column, other things remaining the same, the stronger must be the latticing. Even in the best design, however, it is a question how much the ultimate column load can be carried above the elastic limit of the metal. When all these matters have been satisfactorily determined by tests of full-size columns, it need not be surprising if it be found that some of the very high working stresses for steel bridge columns used during the past few years should be materially modified in future practice.

Smokeless Combustion.

The paper by Professor Breckenridge abstracted in The Engineering Record two weeks ago is an exceptionally clear setting forth of the principles of practical combustion, which, upon the whole, are very far from well known to the public. Even well-trained engineers have generally given far less attention to the theory of furnaces than to the thermodynamics of engines, yet if one reflects upon the matter it is to the furnace that one often has to look for improvements in economy. The best modern engines perform very creditably, considering the limits of absolute temperature within which they work, and improvements have been concentrated of necessity upon increasing the temperature range. Yet there has been and still is general loss at the boilers of an amount of energy that is really serious. A plant must be judged by its performance, and the ultimate criterion is not the steam required per horse-power-hour, but the cost of the coal and firing necessary. One can save more money by learning how to use cheap fuel economically than by attention to the last finical items of steam economy. And by and large it is a fact that fuels differ far less in absolute theoretical evaporative power than in ease of practical utilization. Less than 20 per cent. separates the first-class Welsh steam coal from lignite, so far as actual heat of combustion goes.

When, in addition to economical burning, absence of smoke is required, the plot thickens. As Professor Breckenridge points out the usual source of smoke is not the carbon of the coal as such, but the carbon contents of the hydrocarbons which form the volatile element of coal. In some Western lignites the volatile matter may run up to even 50 per cent. If, now, there is an insufficient air supply or if the temperature is too low, the hydrogen of the distilled hydrocarbons grabs the available oxygen, leaving the carbon to be carried out by the draft as smoke. With inadequate air supply, moreover, the carbon, if ignited at all, goes mainly only to carbon monoxide and two-thirds of its available heat escapes up the stack. It is not at all the actual carbon lost in the smoke that should trouble one, but the indication given by the smoke that the general process of combustion is going on badly. Professor Breckenridge shows that it is doubtful if even one per cent. of the carbon in the fuel is actually lost as smoke, while the fact that smoke exists may indicate really serious loss. And it is of fundamental importance that the fuel should not only be completely burned, but burned with the minimum amount of air that will actually suffice completely to burn it. The average man does not stop to think that every pound of coal burned requires practically from 15 to 20 pounds of air for its combustion. Too much air or too cold air causes loss just as certainly as too little air and is quite likely to produce smoking.

Smokeless combustion, then, is not at all a mystery, but depends on rather simple things. The fuel, if rich in volatile matter, must be so burned that the gases will come off at a uniform and not too rapid rate; they must have plenty of very hot air for their complete combustion; and they must not be chilled by contact with cool surfaces before combustion is complete. The first requirement shows at once why mechanical stokers do so well on fuel rich in volatile matter. With such a stoker the evolution of gas from the coal may proceed at a regular rate so that a carefully adjusted air supply may all the time be effective. The second consideration also points to the use of mechanical stokers so that the process of combustion may go on behind closed doors and in a combustion chamber never chilled. The third requirement implies a furnace of ample dimensions so arranged that the air and gases may be thoroughly mixed and burned before they are cooled by the heating surfaces of the boiler proper. Right here is where the experiments at the University of Illinois come in. It is interesting to note that some of the commercial types of water-tube boiler proved to have been so well designed as to furnace construction that they could be made to work admirably with a proper mechanical stoker, giving almost perfectly smokeless combustion. In other cases a furnace with fire-brick roof proved admirably effective, giving the gases opportunity for complete combustion under very favorable conditions before they passed on to the tubes. Hand-firing was found to give rather poor results, and by passing to machine stoking it seems clear that the rate of combustion, and hence the output, can be greatly increased with smokeless combustion.

This corresponds with the general feeling among engineers that machine stoking does its very best work with the rather poor coals of large volatile content. A very interesting part of the investigation was the study of fire-tube boilers. The old horizontal tubular or return tubular boiler has done good service in the East for many years. In fact, with high-grade coal it has given as high evaporative efficiency as any of the later types. But, as Professor Breckenridge shows, with bituminous coal, such as is found in Illinois, the tubular boiler is a smoke nuisance. Its heating surfaces are altogether too near the fire, and the situation could be helped only by using special low-set stokers and settings specially designed to keep the gases away from the boiler plates. By such extraordinary care it was possible to get even these boilers to do good work with Illinois coal, but generally they have a bad record. Washing the coal, which removes a good deal of ash and sulphur content, has a good effect in promoting clean combustion, although washing cannot compensate for a bad furnace. A most interesting subsidiary feature of Professor Breckenridge's paper is his note on smokeless combustion for residential heating. He believes that with suitable heaters clean and smokeless combustion can be secured, thus solving one of the serious domestic problems of the future. The rapidly decreasing store of anthracite will soon bring the necessity of using bituminous coal for most domestic purposes, and the time to study methods of proper combustion for it is right now. It is such experimental work as that here considered that brings the work of the university home to everybody, and shows the practical usefulness of experiment stations.

Some Educational Problems.

A careful reading of the second annual report of the president of the Carnegie Foundation for the Advancement of Teaching will show what a powerful influence that body is bound to exert on American higher education. Surprise has been expressed from time to time that Dr. Pritchett was willing to resign his high office as president of the Massachusetts Institute of Technology to become the head of a body engaged in charitable work; his report, just issued, shows that the Carnegie Foundation has functions far above those of merely pensioning eminent instructors who retire for one reason or another from active educational work. The document is one of the most clear and clever analyses of educational conditions in the United States that has ever been published. The trustees of the gift of Mr. Carnegie have decided that the true task of their board is not to pass upon the merits of individuals, but of colleges; to decide upon such educational standards as seem fair and wise and then to proceed to admit to the Carnegie system of retiring allowances such institutions as, complying with these standards, come within the provisions of the charter and the deed of gift. In a word, the Carnegie Foundation for the Advancement of Teaching must be first an educational agency before it can act wisely in awarding pensions. Many of the subjects within this broad field, which are considered in the annual report, while bearing on the general purpose of the work of the trustees do not directly affect engineering education, but one of the chapters, on the function of college requirements for admission, is of importance. The variation in the actual requirements for admission to the various colleges which teach engineering in this country is so great that the quality of the instruction which the average student receives before he obtains his bachelor's degree is variable. "In many institutions," according to Dr. Pritchett, "the anxiety to retain students in order to meet current expenses makes the progress of the student through the four classes partake of the nature of an honorary course." A feature of engineering education not referred to by Dr. Pritchett, which bears on this statement, is that in state-aid colleges, which do not receive help from the Carnegie Foundation, it is not always practicable for political reasons to restrict the number of students to those who are really competent to carry on their work. Any college which relies for most of its funds upon grants from a legislature is just as badly hampered as one which must keep all pupils in its classes in order to obtain their money.

The general problems of the requirements for admission to a school of higher education seem likely to be materially restricted by the determination of the trustees of the Carnegie Foundation to throw the light of publicity on some of the defects of existing conditions. It was necessary for the Carnegie Foundation to reduce to a common method of expression the various statements made by the 950 colleges, universities and technical schools in the United States and Canada, and, furthermore, to define the amount of preparation which a college ought to demand of those entering it. It was manifestly unjust as well as unpractical to base a definition of what constitutes adequate training for college work upon any theory, and consequently the trustees of the Foundation have adopted a definition based upon the present standards of the best high schools. These require the pupils to recite on the average four studies daily five times a week. Assuming a study followed for one year with recitations five times weekly as a unit, the ordinary high school course will therefore furnish in four years sixteen such units, and some of the American colleges require as much work as this for admission. Taking into consideration the need for reviews, for possible changes in study and other conditions likely to arise, Dr. Pritchett and his associates have decided that fourteen such units seem a fair measure of the work of the high school and have been adopted as the standard which the trustees of the Carnegie Foundation require for college entrance examinations. If a college requires less than fourteen of these units for admission to its freshman classes, a strong presumption is thereby raised, according to Dr. Pritchett, that the college is devoting part of the time of its classes to instruction in subjects which, in a well-organized educational system, are now left to the high schools. This subject is discussed at much length in the report and after reading the statements concerning it in that document, it seems clear that the average technical college in the United States certainly does not require for entrance standards of scholarship anywhere near as high as those demanded by the best colleges and universities for entrance to their academic courses. There is substantial agreement as to the nature of the studies which a candidate for collegiate standing should offer, but as to the amount of work he ought to have accomplished in these studies before his admission, there is every conceivable variety of requirement.

The relation of efficiency to cost in colleges and universities receives special attention in Dr. Pritchett's report. There are in the United States nearly 200 institutions called universities with annual incomes varying from $4,000 to $1,500,000 and institutions bearing the name of college have incomes ranging from $800 to $238,000. It is self-evident from these figures that there are some institutions of so-called learning in the country which ought to be immediately eliminated from the roll. Every once in a while statements appear concerning the number of successful men who come from weak colleges, and possibly there are a few people who really believe that a college with inadequate funds and incomplete facilities is a better place for a young man to study than one with an income ample enough to supply all the equipment and teaching force necessary to conduct higher education in an efficient manner. While the size of a college is no criterion of the quality of its instruction, there is an absolute dependence of good instruction on fair remuneration of teachers. It is important to observe, however, that those great institutions of learning which have the largest incomes seem in most pressing need of additional funds. The number of courses of instruction has multiplied, the introduction of laboratory methods of instruction has raised greatly the cost of giving such instruction, and the increase of salaries of teachers has been advancing rapidly. The trustees of the Carnegie Foundation are therefore obliged to consider the effect of the mere question of raising money upon the larger and deeper interests of many educational institutions. "Sooner or later a point will be reached," Dr. Pritchett reports, "in which the economic administration of these sums must have a larger share of attention, and when it will be more to the credit of an institution to work wisely with a fair income than to go continually before the public for the means of expansion." It is pointed out that academic freedom has sometimes been interpreted to mean academic egotism, and that really there is a need for business criticism of the financial affairs of American colleges and universities. The tendencies which in a business organization make for expense are all present, while the checks upon them are wanting. Another factor must be considered, the unlimited competition which has been going on for many years between colleges. Dr. Pritchett frankly states that not only have we begun many more universities than we need, but ambitious high schools are not content to do the work of the high schools, but seek to be colleges; the colleges in their turn are not content with the work of the college, but seek to be universities. A number of technical schools have been founded with the distinct purpose of furnishing an elementary technical education for the machinist and the foreman, but almost without exception they have transformed themselves into high-grade technical schools for the training of the engineer, the architect and the chemist. The result has been not only a great increase in cost of instruction, but what is still more to be regretted, a neglect of the more elementary educational work which most needs attention. There is no statement in this very important report which will be more generally approved by engineers than that to the effect that "to-day the United States is well supplied with schools of technology, but it is in pressing need of schools for industrial training for those who desire to enter the trades."

The Wood Preservers' Association.

The annual meeting of the United States Wood Preservers' Association at Kansas City last month calls attention to the fact that the business of preserving timber has at last begun to assume the proportions it urgently needs. There are reasons for expecting that the same development which occurred in the Portland cement industry some dozen years ago will shortly be evident in the utilization of our timber resources. The Forest Service of the Department of Agriculture has sounded a note of warning a good many times lately regarding the rapid depletion of our forests and the wasteful use of timber. Unless the figures given out from time to time by Mr. Pinchot are all wrong, and nobody questions that they are at least approximately correct, the present wasteful methods of employing timber are a grave menace to our prosperity in several directions. Attention has been called many times lately to the growing scarcity of wood for various purposes. In The Engineering Record of April 20, 1907, a valuable report by Mr. Lincoln Bush, chief engineer of the Delaware, Lackawanna & Western Railroad, pointed out the serious conditions of the tie supply in the North Atlantic States, yet the tie situation, important as it is, is only one aspect of the general problem of economy in the utilization of timber. It is not only necessary to use timber of poorer species than were formerly employed, but it is also imperative to preserve the wood employed for a good many purposes so as to secure from it the longest life possible. Wood preserving is an old science, speaking generally, but it is fairly certain that great progress will be made in it now that the necessity for it is more generally recognized.

The United States Wood Preservers' Association is evidently intended to act as a clearing house of information concerning progress in this important art. At the recent meeting there were two papers presented which are likely to prove of much value in helping forward improvements in treatment. One of them, by Mr. David Allerton, superintendent of the Marion, Ill., plant of the American Creosoting Co., described some important investigations with Douglas fir, a wood that is very refractory to treatment and at the same time quite subject to decay. At this plant experiments have been in progress for nearly a year for the purpose of determining the method of securing the maximum penetration of the creosote with the specified amount of that preservative to the cubic foot. Three methods of preparing the timber for the injection of the creosote were tried: 1, Steaming the timber with dry steam and afterward applying a vacuum; 2, same as 1, repeated at short intervals; 3, boiling the timber in creosote. In every case the same objection was found. With green timber difficulty existed in removing the excess of water, the fiber was injured and it was practically impossible to inject over 7 lb. of creosote to the cubic foot. With seasoned timber the fiber was injured and the same difficulty was experienced in injecting the oil. The method finally adopted in the case of seasoned fir is to place the wood in a steel retort and turn the steam into the coil, the creosote being introduced at a temperature of 170° Fahr. The wood is kept at this temperature about an hour and pressure is then started very gradually, the idea being to allow the injected oil to follow the expanded and heated cell. In this way it is possible to obtain a penetration of 2 to 4½ in. in piling by a treatment occupying from 12 to 14 hours. In treating green fir, the preliminary treatment is the same as that for seasoned fir, except that the water in the wood will be expanded and replaced by the heavier creosote, and rising to the top of the retort, will be drawn off through a stand-pipe. After 12 hours of pressure the oil is drawn off and the wood and retort cooled for 12 hours, when the process is repeated, pressure being maintained for 12 hours. It is invariably found that the most oil is injected in the first 12 hours, but the greatest penetration takes place in the second 12-hour period. The second process, consuming 36 hours, is not considered desirable unless necessary. The important thing mentioned by Mr. Allerton is that both processes require skilled help or the supervision of an expert, for if temperature and pressure are not properly regulated, the result will not be satisfactory. The second paper was by Mr. E. D. Fulks, of Von Schrenk, Fulks & Kammerer, consulting timber engineers, of St. Louis. This paper described an investigation of the creosote in old treated timber and led up to a specification for creosote oil which they have recently adopted in their practice. Both papers show clearly how much research can be done to advantage in this art and how useful the Association can be in spreading a knowledge of such investigations.

Some idea of the extent of the wood preserving business at the present time in the United States can be drawn from figures presented at the meeting. The creosoting process was used in 1906 in treating 11,720,000 cu. ft. of timber and 1,837,000 cross ties. The zinc chloride process was used in treating 2,630,000 cu. ft. of timber and 14,169,000 cross ties. The zinc, glue and tannin methods were used in treating about 100,000 cu. ft. of timber and 908,000 cross ties. It is now recognized that cross ties which are not treated are likely to prove decidedly uneconomical, and it seems but reasonable to anticipate that with the rapid rise in their cost and the absolute necessity of using comparatively inferior woods, the treatment of ties will soon grow at a very rapid rate. In the same way the treatment of piles and timber for many purposes is certain to spread rapidly and there is bound to be a great increase in the attention paid to the art, so that the time is at hand when it will be studied with the careful and competent attention which an intricate technical process demands.

An Engineering Appointment of more than general interest was the recent designation by Mayor McClellan of Mr. J. A. Bensel as the member of the Board of Water Supply of the City of New York to succeed Mr. J. Edward Simmons. At the first meeting of the Board after his appointment he was elected its president, and is thus the head of the greatest water supply undertaking of the country. Mr. Bensel's career as an engineer is well known to many of the readers of The Engineering Record. His specialty has been dock construction, in which he long ago attained a position of high distinction. For some time past he has been the Commissioner of Docks and Ferries of New York City, and in that position has shown executive ability of a high order, so that his appointment to the Board of Water Supply is not to be looked upon as another experiment to ascertain if an engineer can succeed as an executive in charge of a great municipal department. Judging from his record as a commissioner and previously as the chief engineer of the Dock Department, the City of New York is to be congratulated on his promotion to the important office he has recently assumed. This journal believes that his management of this office will prove highly successful.

The Flanged Ends of large drums which have to withstand a heavy inside pressure should be examined with the greatest care before they are used, for in their manufacture there is a tendency to weaken the metal at the sharp bends between the main portion of the plate and the flange. Dished heads are used so often for drums which must withstand a high bursting pressure that attention was called to this danger in The Engineering Record some two or three years ago. The incident which suggested the previous warning was a weakness in a head that had been dished by a spinning process. The trouble can also be caused in another way, recently emphasized by an investigation by the Board of Trade lasting nearly a year to determine the cause of the explosion of a thermo-storage drum forming part of a boiler plant of an electric station at East Greenwich, England. This drum was 5 ft. in diameter and 22½ ft. long. A slight leak was discovered in one of the end plates, and while it was being investigated the drum exploded, killing two men and doing much damage. The plate was blown completely off, the fracture being around the plate where the flange had been turned over. The investigation just finished showed that the plate was weakened at the bend between the flange and the main portion of the head by being indented on the inside by the riveting machine while the head and shell plates were being riveted together. The action of the machine was to produce a series of depressions in the head all around the circumference, thus weakening the plate materially. Tensile tests of the metal from the main portion of the head show that it was of an excellent quality, but strips which were cut radially so as to include the bend broke like pot-metal at the bend. Various explanations have been advanced to account for this failure of the steel where it had been subjected to the deforming action of the riveter, but the important fact is that the metal was unquestionably weakened at precisely the point which this journal has previously indicated to be a danger point.

PRELIMINARY WORK ON THE LOS ANGELES AQUEDUCT.

The preliminary construction on the Los Angeles aqueduct has been prosecuted as vigorously as the available funds would permit since the decision to undertake this great work was definitely affirmed early in 1907. This aqueduct is one of the most extensive projects in water-supply engineering that has been undertaken in this country. The project contemplates securing a water supply for Los Angeles from the Owens River and its tributaries by means of an aqueduct about 215 miles in length and with a net capacity of delivering 400 cu. ft. per second, a total fall of 3,500 ft. being introduced in this distance. The location follows through a region of rough country, which includes several spur ranges of mountains, while near Los Angeles it passes through the Coast Range Mountains. The reasons why such a distant source is the only one available for a supply for Los Angeles were outlined in The Engineering Record of Nov. 3, 1906, and a somewhat complete description of the proposed works was given on Jan. 25, 1907.

The Owens River has its source in the perennial snow fields on the eastern slope of the Sierra Nevada Mountains, which is the loftiest range on this continent, and flows generally south to its mouth in Owens Lake, a large body of brackish water. The supply available from this stream and its tributaries was fully discussed in the previous articles. This supply can be made sufficient by development to render dependable a continuous flow of 410 cu. ft. per second in years as dry as any that have occurred in the watersheds of adjacent streams in the past seventeen years during which gagings have been made.

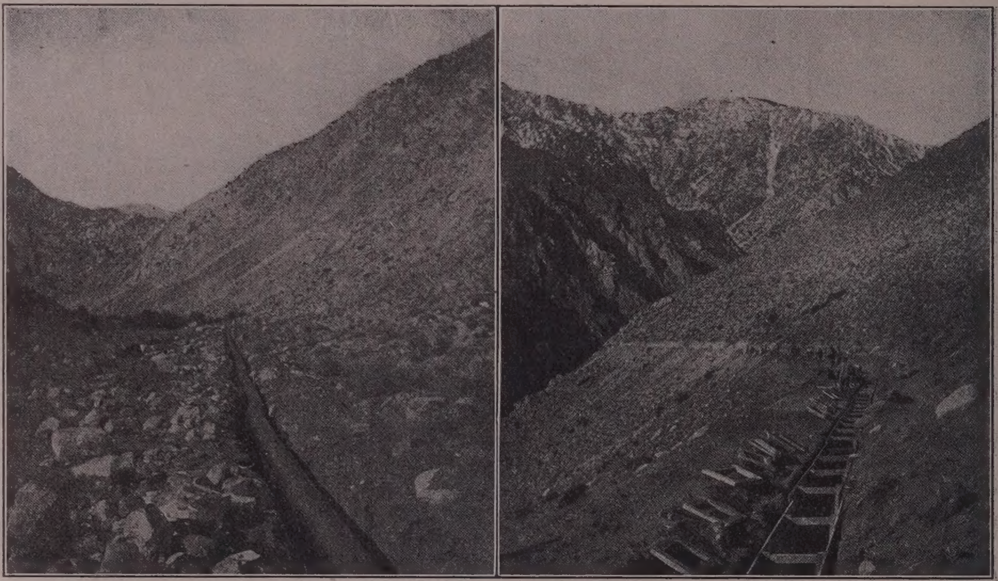
Briefly, the plan to deliver the supply to Los Angeles contemplates the construction of the 215 miles of aqueduct, with a capacity of delivering 400 cu. ft. per second continuously, and various auxiliary structures along this aqueduct. The intake of the aqueduct is at a diversion dam across the river about 40 miles above the mouth of the latter in Owens Lake. A main canal, 60 miles long, leads along the base of the foot-hills from this intake to a reservoir site at Haiwee Meadows. The capacity of this canal is increased from 700 cu. ft. at the upper end to 900 cu. ft. per second as the tributary streams are crossed, permitting a large percentage of the flood waters from the mountains to be delivered to the reservoir. The site of the latter is such that 63,780 acre-feet of water can be impounded by the construction of two earthen dams, having a maximum height of 70 ft.; by carrying these dams 10 ft. higher the capacity may be increased to 82,350 acre-feet. An average fall of 1 ft. per mile can be obtained in the canal with the 70-ft. dams, while the higher dams reduce the total fall in the 60 miles to 50 ft.

Within 15.5 miles from the Haiwee Reservoir, extending to Little Lake, a fall of 310 ft. occurs on the line of the aqueduct. When the demands justify the development of power, 270 ft. of this drop may be made available for such purposes. In order to reduce immediate expenditures, however, this 15.5-mile section will be constructed as a masonry-lined open conduit following a steep natural gradient which permits a small cross-section to be utilized. A new line of conduit which will concentrate the fall for the development of power can then be built later. In the next 24.5 miles beyond Little Lake to Indian Wells the aqueduct must be carried along the steep sides of the valley, 200 to 500 ft. above the highway in the latter. A series of tunnels, inverted siphons and heavy bench cuts, largely in solid rock, are required in the distance. For 20 miles from Indian Wells the aqueduct passes through a smooth, open valley in which the construction will be comparatively easy. The 21.5 miles of line from Indian Wells Valley to Red Rock Canyon involves the second section of difficult construction. This section requires 8 miles of tunnels, 3.5 miles of steel-pipe conduit and inverted siphons and 10 miles of concrete-lined and covered conduit. One of the siphons in this section, at the crossing of Jawbone Canyon, will be under a maximum head of 850 ft. The excavation for this 21.5 miles of difficult work is, however, largely in good material that is easily handled, although the topography is broken. Beyond this section of difficult work the aqueduct will be in level country in the Antelope Valley, through which a canal may be built for 64.5 miles. This long level plain has only two breaks, the total length of the rougher country in the 64.5 miles being 6 miles.

The open canal will terminate in the Elizabeth Lake tunnel, through the Coast Range. This tunnel is the largest single piece of construction on the aqueduct, as it will have a total length of 26,863 ft., and a horseshoe-shape cross-section with a clear height and width of 10 ft. 8 in. From the lower end of this long tunnel the water will for a time be discharged at an elevation of 2,923 ft. above the sea into a narrow precipitous gorge in which it will flow for 11½ miles through the rugged portion of the Coast Range, and will then be diverted at an elevation of 1,520 ft. It will be possible to divert the water from the lower end of the Elizabeth Lake tunnel through a system of tunnels and pipes, 11 miles in length, and thus obtain a gross total head of 1,156 ft., which can be utilized in two hydro-electric developments. The latter, with the quantity of flow made available by a regulation reservoir just above the tunnel, can produce about 49,000 h.p. continuously, or carry a peak load of 93,000 h.p.

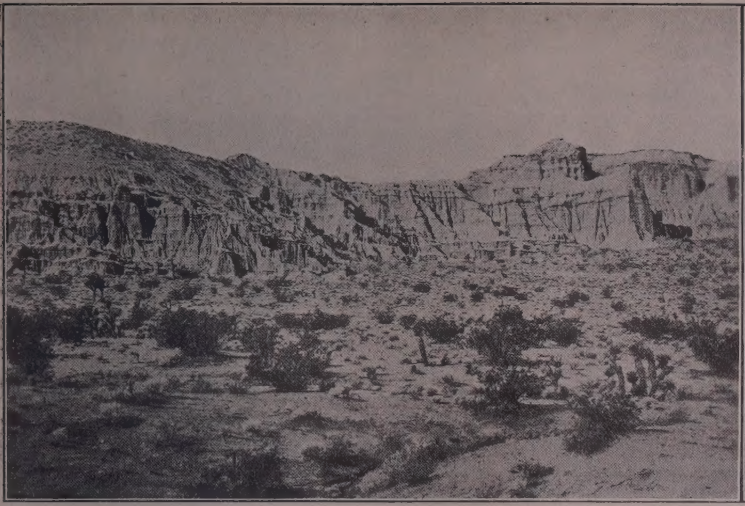
From the point of diversion below the site of the second hydro-electric development the water will be conducted through 4 miles of tunnels having a capacity of 1,000 cu. ft. per second. One of the tunnels in this distance will have a total length of 7,800 ft. The water will be delivered from the last of these tunnels into a reservoir in a canyon, which reservoir is provided to regulate the fluctuation in flow again to a mean 430 cu. ft. per second. A conduit of this capacity will be extended from this regulating reservoir for 11 miles to two reservoirs in the San Fernando Valley, not far from the headworks of the supply conduits of the existing water-works system of the city on the Los Angeles River. These reservoirs will have a capacity of 34,820 acre-feet of water, equivalent to a flow of 96.4 cu. ft. per second for six months. They not only provide a reserve supply at the end of the aqueduct, but also permit the hydro-electric developments above to be operated during the rainy season without wasting water. Furthermore, the water required for irrigation and domestic consumption in and around Los Angeles may be delivered from them at a rate of 500 cu. ft. per second in the six dry months and at 300 cu. ft. per second during the six months of the rainy season.

The work done during the past year in prosecuting these plans as outlined has been confined chiefly to making location surveys, developing an engineering and construction organization and starting, or preparing to start, work on the controlling features of the construction. Although sufficient funds had not been made available to undertake construction on a large scale, nor was it advisable to do much heavy work prior to conducting the necessary investigations, much preparatory work has been finished, plans for construction plant have been consummated and construction on several important parts of the project has been well started. All of the plans for construction that have been made and the work that has been done thus far have been carried ahead with the view that the intricate and difficult parts of the aqueduct may be built by the forces of the commission, while the remainder will probably be awarded to contractors.



Two Views on Diversion Conduit of Cottonwood Creek Power Development.

The isolation of parts of the aqueduct from railroad facilities, resulting in an excessive cost of delivering materials and supplies, and the large expense of power generated by steam at practically all parts of the line are two of the chief difficulties to be overcome in the construction. The Southern Pacific Railroad has a narrow-gauge line extending down the Owens River valley from a connection with the Central Pacific Railroad in Nevada, and this line is the only railroad in that region. Although the narrow-gauge line parallels at a distance of 3 to 5 miles the canal which will form the upper 30 miles of the aqueduct, it terminates on the opposite side of Owens Lake from the Haiwee Reservoir site. From this terminus to Mojave, a distance of 120 miles, no railroads exist and the aqueduct location is through a barren, desert country. Bids for hauling materials and supplies through this region have been invited twice, the tendered price on both occasions being 28 cents per ton-mile. Since the necessary haulage is estimated to average 2,500 tons per mile of aqueduct, the cost of wagon transportation in the flat, desert region would exceed the cost of building the aqueduct. A loca-



Typical Bad Lands, near Red Rock Canyon.

Freighting Teams in the Mojave Desert.

tion survey for 139.3 miles of railroad, extending from Mojave to the south end of Owens Lake, had been made by the engineering department of the Aqueduct Commission and estimates have been prepared on the cost of building this railroad. Based on these estimates, the cost of moving the approximately 20,000,000 ton-miles of freight that must be handled between Mojave and the Owens River points will be 10 cents per ton-mile, if the equipment is sold at the completion of the work.

For various reasons the commission desires to avoid the construction of this railroad, so negotiations were entered into with three railroads having lines in operation, or under construction in California. As a result of these negotiations the Southern Pacific Co. made a definite location survey from Mojave to a point on the narrow-gauge railroad in the Owens River Valley. Bids for the construction of this railroad and the transportation of the aqueduct freight were opened Jan. 10, last, but at the time these notes were prepared no definite action had been taken on the tender made at that time. The construction of such a road will provide a new outlet from Los Angeles to the East by way of the Central Pacific connection in Nevada. It will also make commercially tributary to Los Angeles a large undeveloped region rich in mineral resources and a considerable irrigated agricultural region in the Owens River Valley.

Since the cost of hauling by teams along the line of this proposed railroad is so excessive, it is deemed unwise to attempt much construction in the section between Mojave and Owens River prior to building the railroad. Every effort is therefore being made to expedite the construction of the railroad and the present intention is to delay extensive work on the aqueduct in this region until the railroad is built from Mojave to Red Rock Canyon. This covers the most expensive and difficult portion of the railroad, and as soon as it is done the heavy work on the aqueduct in the vicinity of Jawbone Canyon will be opened.

Between Mojave and Fernando, near Los Angeles, the aqueduct is at all points within hauling distance of the Southern Pacific Railroad, although some of the hauls are long. The Southern Pacific Co. has granted to the city for the construction of the aqueduct one-half class rates on all local freight and the creation of terminal points along the line of construction. These rates apply at practically all points contiguous to the aqueduct, and are made under the Federal laws permitting special rates to be granted to municipalities. The Atchison, Topeka & Santa Fe Railroad has granted similar rates to the city, but the only shipping point on the aqueduct to which this railroad can deliver is Mojave. These half and terminal rates will save the city probably $200,000.

In the unoccupied desert region between Mojave and Owens River, where forage and subsistence supplies all have to be brought in, the cost of feeding a horse is from 50 to 70 cents a day. The cost, transportation and maintenance of labor are also high. These conditions render particularly imperative the provision of ample mechanical power to excavate the canal, to drive the tunnels, to hoist material up the steep mountain sides and so forth. Provisions have been made to supply power to drive all of this necessary equipment electrically, without depending on steam-driven stations operated at a high cost. A hydro-electric development has been made by the commission on Division Creek, near the intake of the aqueduct to furnish power to operate a suction dredge to be used in building the first 23 miles of the canal. A second hydro-electric development has also been made by the commission on Cottonwood Creek, 47 miles below the intake. Power from this development will be transmitted along the aqueduct to Mojave, 90 miles distant, and will be utilized wherever needed to drive the construction plant. The balance of the line will be supplied with power by the Los Angeles Edison Co. from the high-voltage transmission line extending to Los Angeles from the Kern River hydro-electric development of that company. Ample power will thus be obtained for the entire project, and this power can be delivered over transmission lines as electrical energy from central stations so readily as to make any other possible method of supplying power incomparable in cost and convenience.

The hydro-electric development on Division Creek has been made by building a diversion dam and head-works in the stream 5,700 ft. above the site of the power house. Water is conveyed from this dam to the power house by a 12-in. steel pressure line, which delivers it under a head of 460 ft. The power house has a concrete base covered by a temporary superstructure, with corrugated-iron sides and roof, the equipment all being on concrete footings. The unit that has been installed consists of a 125-kw., three-phase, 60-cycle, 15,000-volt Westinghouse alternating-current generator belt-connected to a Doble tangential water wheel. The current is transmitted at the generator voltage over a line carried by locust poles cut from the city's property. The estimated cost of this development at the isolated site is only $16,290. After the development has served its purpose for use in the construction of the canal, it can be utilized during low surface flows in the streams to supply power for pumping water into the aqueduct from ground-water sources.

The dredge to which power will be supplied from this development has a 20 x 55-ft. steel hull having a ladder frame at the front end to carry the suction pipe of the pump. The latter is of

Typical Side Hill in the Grapevine Country.

South Portal of the Elizabeth Lake Tunnel.

the 12-in. Byron Jackson centrifugal type, built specially for dredging purposes. The discharge of the pump is attached to a vertical Y connection, which permits the output of the pump to be delivered on either or both sides of the channel in which the dredge is working. The pump is belt-driven by a 75-h.p. 550-volt variable speed induction motor, the high-voltage current from the transmission line being stepped down to 550 volts by transformers towed on a float following the dredge. Before this dredge was shipped to the point where is was to be used, it was erected in a reservoir near Los Angeles for a thorough test with very satisfactory results.

The hydro-electric development on Cottonwood Creek will operate under a total head of 1,200 ft. made available by a diversion conduit 9,000 ft. long. This diversion line consists of 6,000 ft. of covered concrete conduit, and 3,000 ft. of 24-in. riveted-steel pipe. The line leads to a penstock which is 22 in. in diameter and is made of steel plates varying from 3/16 in. to ½ in. in thickness. The power house at which the penstock terminates is similar in construction to the one on Division Creek, providing space for two water-wheel-generator units, although only one of the units is to be installed immediately. The penstock is large enough, however, to supply sufficient water to operate both wheels.

The unit being installed consists of a 1200-h.p. tangential Pelton water wheel, direct-connected to a 3-phase, 60-cycle, 2,300-volt Westinghouse alternating-current generator. The power generated in this station will be stepped up to 30,000 volts by transformers in the building, and will be transmitted along the aqueduct at that voltage. The transmission line will consist of three copper wires carried by built-up poles, each consisting of a 5 x 5-in. timber, 10 ft. long, attached at the bottom to four 2 x 4-in. timbers, 18 ft. long, which are spread to 16 ft. apart at the base. The 30,000-volt current will be stepped down to 550 volts for use at various points along the line as required.

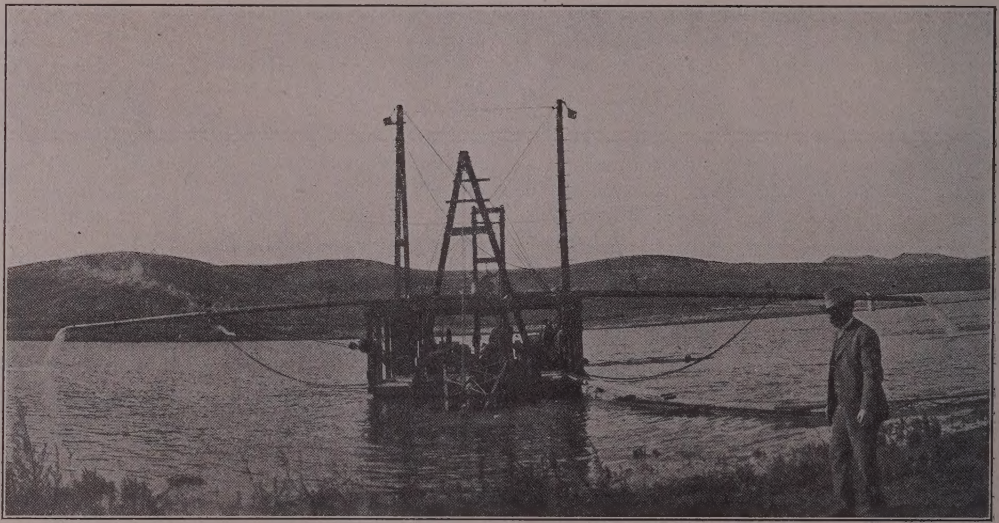
A considerable amount of construction work had been done on this development when these notes were prepared. The steel pressure pipe was largely delivered and was being placed, the construction of the concrete conduit was in progress, and the power equipment and the material for the transmission line were arriving and being installed.

The principal other construction work that has been done on the upper end of the aqueduct is the preparation under way to build the two earthen dams of the Haiwee Reservoir. These dams will require between 280,000 and 300,000 cu. yd. of material, which can be obtained at the site at such an elevation that it can be delivered in place readily by the hydraulic-sluicing process. One of the dams is at one end and the other at the opposite end of the reservoir site, which is comparatively long and narrow, with a slope toward both ends. A pipe line, 19,500 ft. long, is being built to the south dam from a point on a creek near the site. This pipe line is 6 and 8 in. in diameter, and will render available a total head of 1,040 ft. Most of the trench for this pipe line has been excavated, part of the pipe is on the ground and the remainder is at Mojave awaiting transportation by teams over the intervening 90 miles of desert country. Investigations have also been made at the site of this dam, which revealed conditions favorable to the construction of the latter.

Along most of the balance of the aqueduct as far as Elizabeth Lake tunnel preliminary work only has been done, consisting of the construction of wagon roads, the development of water supplies for the construction forces and stock, the erection of suitable quarters for the engineers and so forth. The difficulty of obtaining an adequate quantity of good water in the desert region is shown by the work done near Red Rock summit. At this point a pipe line, 73,000 ft. long and varying from 2 to 3½ in. in diameter, has to be built to the line from two springs and a small creek near the head of an adjacent canyon in the Sierra forest reserve. Permission had to be obtained from the Government to take the water from these sources. The water thus obtained is necessary for mixing concrete along the aqueduct, as well as for domestic purposes and for stock, and as it is the only one available in the locality it will be piped in both directions along the aqueduct as is required.

Another water-supply development in the Jawbone Canyon further illustrates the difficulty of obtaining a sufficient quantity to supply the demands that will be created during construction. A 60-ft. well sunk in the canyon 2½ miles above the point where the aqueduct crosses the latter furnishes a considerable amount of good water. The latter is delivered to the site of the crossing by a 4-in. pipe line and will be distributed along the aqueduct in both directions. Arrangements have also been made to continue this line about 3 miles to the mouth of the canyon, in order to supply the freighting teams passing that point.

The electrical power purchased from the Los Angeles Edison Co. will be delivered at a point about 17 miles below the Elizabeth Lake tunnel as 33,000-volt, 60 cycle alternating current. A transmission line will be built by the Aqueduct Commission in both directions from this point of delivery, extending from a point 10 miles above Mojave to the lower end of the aqueduct. The power is bought as required at meter rates at a cost varying from 1.175 cents per kilowatt-hour for 100 per cent. load factors to 1.3 cents per kilowatt-hour for load factors under 25 per cent.



Electrically Operated Suction Dredge for Building Canal Section.

Construction work was started on the Elizabeth Lake tunnel in September, 1907, and has been carried ahead from both portals since then as rapidly as the equipment available would permit. Most of this preliminary tunnel work has been done by hand, as a single tripod air drill in each heading furnished with power by a small compressor driven by a gasoline engine at the portal has been the only mechanical equipment installed. On January 1, 305 ft. of tunnel had been excavated and timbered at the north end and 250 ft. at the south end. The work in the north end up to Nov. 30, when 165 ft. was driven, was done at an average cost of $12.50 per linear foot for labor, materials and supervision, and that in the south end up to that time, when 189 ft. had been driven, cost on an average of $14.50 per linear foot for the same charges. The materials thus far encountered in this tunnel are favorable for construction. The cost of the excavation, even with the small amount of plant available, has been well within the estimated cost. The results obtained will also permit a decision to be reached as to whether it will be more economical to drive this tunnel with the forces of the commission, or to award the construction work to contractors.

Since this tunnel is the heaviest single piece of construction on the entire aqueduct, arrangements have been made to install complete mechanical plants at both portals to supply power to the heading driven from each of the latter. If necessary, it is also feasible to sink a shaft about midway on the tunnel and drive headings in both directions from the foot of this shaft. All of the equipment to be used in building the tunnel has been purchased with the view that the construction shaft may be sunk near the center of the tunnel, in which case a power plant containing twice the amount of equipment in each of the portal plants will be installed near the mouth of the shaft.

The mechanical plants at the two portals will have the same equipment, each containing two two-stage 19 x 12 x 14-in. duplex air compressors, each belt-driven by a 100-h.p. continuous-speed alternating-current Westinghouse motor. These compressors were built by the Chicago Pneumatic Tool Co., and each have a capacity to deliver 500 cu. ft. of free air per minute at a pressure of 100 lb. per square inch at sea level, when operating at 110 r. p. m. Each compressor can furnish sufficient power to operate the drills in the heading. The latter will be ventilated by a positive cycloidal Root blower, with a capacity of 5,000 cu. ft. of air per minute when running at 200 r. p. m. These blowers will each be belt-driven by an electric motor. At first, they will be installed near the tunnel portal, but will later be moved ahead as the excavation progresses.

The excavated material will be taken from the headings to the portals in 1½-yd. side-dump Koppel cars, with steel frames and bodies. The axles of these cars are self-oiling and the draw-bars are of the compression-spring type, the cars being designed so they can be hauled at high speeds. The construction tracks in the tunnel will also be laid to permit high speeds to be maintained safely. They will have 35-lb. steel rails in 30-ft. lengths laid to 24-in. gauge. The cars will be hauled by 6.5-ton single-end control Ft. Wayne electric locomotives supplied with power from an overhead trolley. Each locomotive will be equipped with two 250-volt direct-current motors capable of maintaining a minimum speed of 6 miles per hour with a draw-bar pull of 2,400 lb. A motor-generator set, consisting of a 450-volt, three-phase, 50-cycle, 100-kw. Fairbanks-Morse induction motor and a 250-volt compound direct-current Fairbanks-Morse generator will be installed at each portal to supply power to drive the electric locomotives.

Various other motors have also been purchased for use in the tunnel, all of which motors have housings to protect them properly from dripping water and other unfavorable conditions in the tunnel. A gyratory rock crusher and a concrete mixer, both motor-driven, will be installed in connection with both headings. It is contemplated that these outfits will be moved ahead as the concrete tunnel lining is advanced.

Approximately 1,300,000 barrels of cement will be required in constructing the aqueduct, and at the time the work was authorized cement was selling in the local market at $2.75 per barrel. A complete investigation of the available natural lime and clay deposits along and adjacent to the aqueduct was therefore made and estimates of the cost of manufacturing cement were carefully prepared. As the result of these investigations a deposit of clay and two deposits of limestone were purchased. The clay bed covers about 300 acres along the Southern Pacific Railroad, 5 miles east of Tehachepi and 15 miles from the line of the aqueduct. One of the limestone deposits covers 110 acres, six miles from the clay bed, and the other, 160 acres, three miles from the clay bed. Estimates based on the cost of erecting a cement mill capable of producing 1,000 barrels of cement a day from these deposits showed that the cement could be made at about $1.05 a barrel, and could be delivered to the line of the aqueduct at Mojave for $1.24 a barrel.

Usual Type of Desert Country in Antelope Valley.

The decision was, therefore, made to build a mill capable of producing 1,000 barrels of cement a day, so contracts were awarded for the necessary equipment. The latter will all be electrically driven with power generated in a central station to be built in connection with the mill. The power station will contain two 500-kw., 440-volt alternating-current Curtis turbo-generator units, with the necessary auxiliaries. Steam will be furnished by four water-tube boilers, two rated at 500 h.p. each and the other two at 250 h.p. each. The raw materials will be crushed in a No. 6 gyratory crusher built by the Power & Mining Machinery Co. The cement mill proper will contain six ball mills and nine tube mills built by Thos. Prosser & Son; two rotary dryers, three 125-ft. kilns and three 30 ft. rotary coolers built by the Vulcan Iron Works, of Wilkesbarre, Pa. All of this equipment will be separately driven by Westinghouse 440-volt alternating-current induction motors.

The various equipment is already arriving and will be installed as rapidly as possible since it is inadvisable to start the construction of the aqueduct proper in the desert region until the cement is available for the concrete lining and in many places for covering. Under the existing conditions it is expected that cement can be delivered from the mill by September, 1908.

The deposits of raw materials for making cement owned by the city have been determined to be exceedingly valuable and it is believed that the cement mill can be sold after the aqueduct is finished for considerably more than the original cost of the project.

The personnel of the organization of the engineering department of the Aqueduct Commission is made up of men of unusually good training and experience in work similar to that which is to be done. Mr. Wm. Mullholland, chief engineer of the commission, has been connected with the water supply system of Los Angeles as superintendent, manager and chief engineer for over 30 years. He has been in charge of the work on the aqueduct since the inception of the preliminary investigations pertaining to the latter. Mr. J. B. Lippincott, formerly supervising engineer in Southern California for United States Reclamation Service, is principal assistant engineer. The mechanical division is in charge of Mr. Roderick MacKay, and the electrical installations and transmission system are being made under the direction of Mr. E. F. Scattergood. The investigations pertaining to the raw materials for cement were made and the cement mill is being built under the supervision of Mr. E. Duryee. The different divisions into which the construction work is divided are each under the supervision of a division engineer. The engineering parties are organized under the civil service bureau of the city. The construction forces are also being brought under the classified service.

The Coal Resources of the Philippines have been investigated by government geologists, who report that a large vein probably crosses the entire group of islands; it has been clearly traced in one vicinity for fully 25 miles. Mine workings were discovered which had been extensively operated by the Spaniards. The coal is found to be a uniformly good bituminous.

The Necessity of Continuity in the Steel Reinforcement of Concrete Structures.

A paper read before the National Cement Users' Association by Mr. E. P. Goodrich, Consulting Engineer, New York.

Concrete structures exhibit the usual phenomena of elastic solids, especially when they are provided with a skeleton of steel, properly proportioned and distributed throughout the concrete mass, according to circumstances. In the construction of concrete sidewalks and of most retaining walls, particularly if of massive design, special effort is made to reduce within certain limits the size of the parts which will act as units. In some arches, efforts have been made looking toward a similar result, but in structures of that class, the present tendency seems to be to treat them frankly as continuous elactic structures, even though their detailed design is thereby rendered quite complicated. In such structures as lines of concrete pipe, separate units are being employed even when of large diameters, but most work is of the continuous or monolithic variety.

No half-way course is possible between these two classes of structures. If an arch is designed without joints, but the reinforcement is not arranged for a continuous structure, joints are almost certain to form in accordance with Nature's laws by the cracking of the work, and sometimes they may occur at points which even threaten the stability of the structure. At least, they are often exceedingly unsightly. A concrete sewer is out of sight and usually so arranged that there is little danger of collapse, should a few small cracks occur. But in this case another danger may exist. In a small city in a Middle Western state, a sewer was found to have become clogged so that it burst and flooded the cellers of the adjoining property. Investigation showed that a root from a willow tree had entered the sewer through what must at first have been a very small crack, and had multiplied its fibres within the sewer to such an extent as to cause the trouble above mentioned. The matter of building design will be more fully discussed a little later.

From even the two cases above cited, it would seem all important, when a concrete structure is to be constructed monolithic in character, so to distribute its reinforcement as to make it act like a continuous solid, and in its design treat it as an elastic structure subject to stresses and strains from its own weight, from the live load and its impact and variation in intensity, from changes of temperature, local settlement, etc. What follows will be almost entirely a discussion of the subject of continuity, as found in the structural members of buildings, it being taken for granted from this point onward that continuous structures should be erected with reinforcement designed to provide such elastic resistance as the continuous nature of the member demands.

A few concrete buildings have been erected in which the several structural members have been molded on the ground and erected and set in place in the same manner in which timber and steel work is handled. In the majority of cases, however, it has been the endeavor to secure a monolithic structure, and this theoretically monolithic nature has been one of the points much advertised as a great advantage inhering in concrete work. This very condition of perfect continuity has some minor disadvantages. Sound and vibration are transmitted much better than in a less rigid structure, but the greater mass and the inherent nature of the propagating medium tend to absorb the vibrations so that at least one of these disadvantages is usually turned to a favorable property. A much more important point for consideration in this connection is the fact that in structures composed of separate members, innumerable joints naturally exist at which expansion and slight changes of position from deformation can take place without endangering the structure, because brackets and other devices are provided to allow such conditions. The first designers in reinforced concrete were so imbued with the ideas of the older types of structures that they thought of the several members of a concrete building as practically identical with those of all other types.

The first regulations covering reinforced concrete work adopted by municipalities thus viewed this point, as is shown by their specifying that a factor of ⅛ should be used in the design of beams, girders and slabs. Very soon, however, trouble arose in buildings executed in accordance with such designs, which were being loaded to anything approaching their theoretically safe carrying capacity. Cracks occurred in the floor surface at the ends of the beams and girders, and slabs cracked away from beams in the same manner. These cracks were often ascribed to shrinkage or settlement or some other factor, but in many cases were the necessary result of natural deformations of the structure. They showed that the same thing took place in concrete beams as happened in any other kind, but that allowance had not been made for such action. The next step was to require special reinforcements over points of support, to correct this trouble; and in order to secure some hypothesis for determining the amount to be used, advantage was taken of an observed fact that the factor ⅛ could be reduced to 1-10 for various reasons for moments at the centers of beams. Since 1-40 measures the difference between this factor and the theoretical total, the amount of reinforcement thus determined was specified at the points in question.

When thus reinforced, a continuous beam possesses partial restraint at the ends. If a homogenous beam of constant section be considered, and one with a moment of inertia correspondingly less than a beam designed to carry the same total load when supported without restraint, it will be found that the theoretical slope of the neutral axis at either support is to be measured by the numeral 7, as compared with 10 for a free beam. Such a slope would theoretically open a considerable crack at the top of almost any beam. Obviously if this condition existed, the steel designed to carry a moment measured only by the factor 1/40 and at a stress equal to that of the steel near the bottom of the center, would actually be stretched much more than such a stress would deform it. Consequently it would be carrying more than is above considered, with a correspondingly somewhat smaller slope of the beam. In a reinforced concrete girder, however, the moment of inertia is not constant throughout, and consequently the slope would probably be fully as great as first described above, even though the reinforcement was stressed beyond the permissible amount. If this actual stress happened to exceed the elastic limit of the top reinforcement, as may easily happen, a permanent deflection would result in the top of the beam. Furthermore, a similar permanent set would have taken place in the concrete on the under side, below the crack, because of the high compression which would have taken place in the concrete. A repetition of the load would be likely to increase the first increments of deformation, and this increase would continue until a slope had been permanently secured, beyond which the added deflections caused by ordinary loading would not cause stresses above the new elastic limits of either the steel or the concrete.

But in order to attain this state of affairs, the stress conditions in the beam may have far exceeded safe limits, and many observations have shown this to have actually happened in more than one building.

The dangers incident to such tension cracks adjacent to points of support are numerous. They occur where the shear in the beam is a maximum and unless ample reinforcement is introduced to resist these latter stresses (as is really very rarely done), their unit values will run up far beyond limits usually considered safe. These initial tension cracks also serve as starters for others which tend to occur from the diagonal principal tensile stresses. Cracks of the latter variety are apt to develop suddenly, producing destructive failure in test specimens, and there is no reason to suppose that more immunity would be found to inhere in actual structures, should the load ever reach a critical value. With the formation of such cracks, the zone of compression is obviously restricted to the uncracked part of the concrete, and if the crack is driven across the initial position of the neutral axis, the unit stresses in the extreme concrete layer must exceed permissible, safe ones. Then, too, in the cracked condition, the concrete can have no tensile value, and while this element is usually ignored in design work, its practical effect is well known to those who have made tests of beams and who have studied the subject of diagonal tension to any great extent. With a cracked condition, moreover, there is almost infinitely more opportunity for the reinforcing steel to be attacked by rust, with possible further incidental troubles. The few laboratory tests concerning this matter which have been made, principally in Germany, are inconclusive, and are best interpreted by the facts of actual experience, wherein rust has been discovered in connection with very fine cracks, when the metal was not covered with more than ¾ in. of concrete.

The more steel is supplied over points of support (up to the theoretical necessary limit), the more are the above-mentioned destructive tendencies reduced. Of course, with perfect restraint, twice as much reinforcement is required over supports as at the centers of beams. It is needless to state that this condition is almost never attainable at end bearings, although it is often closely approached at intermediate ones in large buildings, especially on the lower floors where heavy column loads give excellent stability to the members meeting at those points. With regard to the latter point, a column 16 in. square and stressed to 300 lb. per square inch, for instance, will resist a moment of 28,800 inch-pounds, without developing tension on one side of the base, if it acts only with its vertical load. This will be equivalent to that of a uniform live load of 832 lb. per square foot distributed over a panel 20 ft. square. Of course such a column, if of any considerable length, would itself be bent to some extent by such a moment. This example tends to show the real action of the reinforcement usually installed and also indicates the necessity of a better form of splice on longitudinal rods in columns than a piece of gas pipe slipped over the ends of the rods. On the upper floors, however, and in wall columns, special reinforcement must be installed if any real restraint is to be secured above that afforded by the tensile strength of the concrete itself.

The same general reasoning applies to slender columns which may be flexed by beams supported by them, as has been given for beams with deficient reverse moment reinforcement. This is particularly true with regard to the columns which have been designed to support long-span, heavy roof girders. There is no reason why such a combination cannot be analyzed, even as to the effect of unequal settlement, and the writer invariably makes an analysis of such designs, on the assumptions of rigid restraint at foundations, no shortening of the girder through its deflection, and ignoring the bending effect on the column produced by the slight eccentricity of its load from the same cause. The problem then becomes one simply of a continuous beam over three spans with restrained ends, the parts having different moments of inertia. The solution is not particularly difficult, and by simple graphical methods the proper arrangement of reinforcement may be readily determined. It is usually found that more column steel is required than had been expected and that less end restraint of the main girders is secured than is often allowed.

Partial loads on continuous members over hinged supports give maximum positive and negative moment curves different from those for full uniform load. In a monolithic structure no supports are as flexible as a hinge should be, and consequently the full values thus obtained can be modified with perfect safety. A considerable study given to the subject seems to show that the amount of steel indicated by the use of 1/12 in computing the moment of a continuous uniform load, placed at both the top and bottom of a continuous member, is ample. The proper distribution may be closely approximated by dividing the axis of a parabola into thirds and making the top and bottom steel overlap the amount shown by the center third. For various reasons, too, it is wise to run at least one rod from end to end of a continuous member along its bottom, in spite of the theoretical wastefulness involved. Some engineers also run one throughout along the top, and this is absolutely essential on short spans adjacent to longer ones. In such cases, a careful analysis should always be made. Even in the floors of ordinary warehouses, deflection experiments show considerable upward movement when alternate bays are loaded. Excessive loads, located in this way, might easily cause dangerous cracking in the unloaded bays, while the loaded ones were perfectly safe.

In a monolithic structure, secondary stresses from local settlement, shrinkage during setting, and changes of temperature are of much greater moment than in buildings constructed of separate members with numerous joints. If local settlement takes place in a column, for instance, there is a tendency to produce worse cracking at points adjacent to the neighboring columns when the beams and girders are reinforced as simply supported ones, than when they are treated as continuous. Much more elasticity is secured, a better distribution of stress and consequent diminished liklihood of annoying cracking. Furthermore, when cracking does occur, it is less likely to be of a dangerous character than when the members are reinforced as simply supported ones.

The shrinkage which takes place from setting is not usually sufficient to cause any trouble, except at such points as connections between floor slabs and the deep ribs of girders and beams; unless very large, long or deep stretches of work are placed in a single operation. Great care should be taken in the arrangement of the reinforcement at such points, the continuous type being altogether best, even for floor slabs. In connection with such slab steel, numerous stirrups should be provided to tie together the stem and the flanges of the T-beam which is the actual statical condition of the member when under load. It may not be out of place to remark at this point that the actual effective width of flange in such T-beams is probably not nearly as wide as is assumed by many engineers. Care should be exercised in the design of the reinforcement of heavy floor girders to see that enough reinforcement runs through the flanges of the T, across the top, to provide for the secondary bending stresses which are developed by the shearing stresses close to the stem. This condition is usually overlooked in connection with the members which run parallel with the floor slab reinforcement. Members running in the opposite direction secure ample assistance from the regular slab rods. Also, in continuous members, for ordinary loads, the neutral axis is so high in the vicinity of points of support that little is to be feared from possible compression failures at such points unless the stress condition within the zone of compression is aggravated by the approach of a diagonal tension failure. The latter is the one shown indirectly as the cause of rupture in all the tests of continuous members with which the writer is acquainted, and to obviate which, special care should be exercised in design work.

That the computed compressive stresses run very high shows either that the confined condition adjacent to points of support makes such stresses possible, or that wrong methods have been used in their calculation or wrong assumptions made on which to base computations. All these are probably true. In designing the reinforcement for such continuous members, care should therefore be exercised to provide as ample steel as possible to assist the concrete in resisting compressive, shearing, and diagonal tensile stresses. Perhaps, it is somewhat beside the point to state here that all tests of continuous members show great deficiency of the original concrete to withstand the developed diagonal tensile stresses without the addition of considerable steel in the form of stirrups or other heavier rods, either vertical or inclined, or both, and properly anchored at the ends. But the reinforcement for few buildings is designed with such an amount of reinforcement at those points and if continuous members are to be considered at all, the present practice is open to considerable improvement. That structures remain standing is no criterion of their proper design and construction. The condition of numerous country highway bridges is a notorious example of the existence and continued use of sometimes actually dangerous structures.

Change of temperature is a potent cause of innumerable, unknowable, secondary stresses in many structures. In such buildings as tanks and long walls in which cracks are inadmissible, absolute continuity of reinforcement is essential. Nothing further need be said concerning such structures, except that it is not usually advisable to reinforce retaining walls so as to prevent cracking. Even where water-tightness is necessary it seems wisest usually to undertake to secure it by the employment of a watertight expansion joint, together with a waterproofing by some method of the portions of wall between joints. To be sure, in one instance of a reinforced concrete face for a high rockfill dam in the Sierra Nevada Mountains, a recommendation was made to carefully reinforce areas aggregating approximately 20,000 sq. ft., rather than to make use of waterproof expansion joints under hydraulic heads over 100 ft. high.

In buildings of relatively small dimensions as to ground area, no contraction joints are necessary, especially in the upper stories. In long buildings, some joints may be deemed advisable in order to obviate the heavy tensile secondary stresses which must sometimes exist, and which show themselves by cracks, sometimes at unsightly and occasionally at dangerous points. In small buildings, the employment of numerous distributing rods through the floors at right angles to the regular carrying rods, will usually be sufficient as far as the floors themselves are concerned. Around window and door openings, special reinforcement should always be provided to prevent the formation of the cracks which often start at all four corners, and extend for short distances into the walls. Roofs are subject to extraordinary changes of temperature in their several parts, and need the greatest of care in the design of their reinforcement, especially when the slabs are treated as the flanges of long-span roof girders.

In larger buildings, clean-cut joints may be installed, and can be placed at the centers of panels by providing cantilever beams and girders half a span in length on each side. Such joints should always be covered with an elastic waterproof coating to shed the water falling on the floors in case of fire.

This discussion has been mainly on the subject of the prevention of cracks, a series of prescriptions for the overcoming of certain symptoms. While simple tension cracks on the bottoms of beams at their centers are not usually at all dangerous, since they commonly develop at comparatively low steel stresses, still the owner is not aware of this fact, and is not readily convinced that there is no real defect when his building commences to crack. He wants a perfect structure and is entitled to receive it, particularly when possible danger of the formation of rust exists when cracks have formed, and more particularly when a slightly different arrangement of reinforcement would entirely eliminate the fancied or real trouble in question. Logic thus seems to dictate that all structures which are at all monolithic in character, thus having members continuous over supports or through floor levels, should have their reinforcement so designed and placed as to make them act under all load conditions as their original monolithic nature would make them start to act.

New York State Water Powers.

On Feb. 1, the New York State Water Supply Commission submitted a preliminary report on the State ownership of water powers and the State control of the flood waters of the large streams. Last year the Legislature authorized the Commission to investigate these subjects and Mr. John R. Freeman was retained to take charge of the technical work. Excluding Niagara and the St. Lawrence, the rivers of the State, with the proper storage of their flood waters, are capable of furnishing at least 1,000,000 h.p., according to the Commission. On account of the wide difference between the minimum and maximum flow of the streams, the minimum flow being the real test of the power value, at least 55 per cent. of their potential energy is believed to be lost, and 550,000 h.p. is wasted because no well devised and comprehensive plan for the systematic development of water power has yet been undertaken by the State. The Commission holds that at a low estimate the advantage of water over steam power is at least $12 per h.p. per year. The annual earning capacity of the wasted energy based on even so low an estimate is $6,600,000. Add to this the $1,000,000 per year of direct damage caused by floods, the indirect damage which is surely equal to the direct damage, and the value of an equalized flow during the summer months in the great rivers, and the aggregate will give some idea of the value of systematic development of the water powers of the State.

The Commission points out that up to this time there has not been, and under present conditions there cannot be, such economical and general development of water power by private interests as will include the storing of flood waters on a scale at all commensurate with the advantages to be gained thereby. It is from this method that the greater amount of increase is to come. Moreover, the individual or corporation that invests money usually does so in the hope of immediate gain. There is, therefore, the temptation to cut out of the work everything that can be postponed or avoided, no matter how essential it may be to the future success of any well considered plan. The storing of flood waters will provide not only power development at the site of the dam, but will also increase the power of every user down the stream. The fear of improving the plant and power of a competitor might well restrain an owner of water power from going further up the stream and building a storage dam that would increase the value of his neighbor's plant as well as his own. It is also very difficult for several interests to combine in aid of such a project. Even though they should be willing to engage in a joint enterprise for such a purpose, there would be still the lack of power to condemn land for storage purposes for which recourse must be had to the law-making body.

The Fuller law, under which the Commission is carrying on this investigation, calls for a comprehensive investigation requiring a long period of time and a large amount of money. It has accordingly concentrated its attention for the present on careful surveys of the Sacandaga River, with a view to building a storage dam near Conklingville, and on an investigation of the practicability of a storage dam on the Genesee River, near Portage. It appears probable that the first dam will flood an area of about 40 square miles and store about 26 billion cu. ft. of flood water; that the Sacandaga River thus dammed will furnish at this point a sufficient amount of water to produce 50,000 h.p., which is greater than the aggregate water power of Lowell, Lawrence and Holyoke combined, or will increase the present available force at sites lower down the Hudson by 70,000 h.p. for the six dry months of the year. The Genesee River project calls for a curved dam 1,200 ft. long on the crest line, and 160 ft. high above the foundation, would flood an area extending 15 miles up the river and averaging a mile in width, forming a lake of 15 sq. mi. surface area, about as large as Canandaigua or Skaneateles Lake. This reservoir would store 18,000,000,000 cu. ft. of water, sufficient to provide a yearly average flow of 800 cu. ft. per second for power purposes. In a line from the dam to the power house a tunnel 3 miles long and 18 ft. in diameter would be built. The net working head at the power plant would be 500 ft., which would permit a gross development of 32,000 h.p., and increase by 14,000 the actual horse-power now developed at Rochester. Such development on a basis of $12 per horse-power per year would produce an annual revenue of $384,000 at the power station and $158,000 at Rochester. Other benefits would be relief from annual damage by floods in the Genesee Valley and in Rochester, and also the benefit to the sewerage of that city by increasing the low water flow of the river.

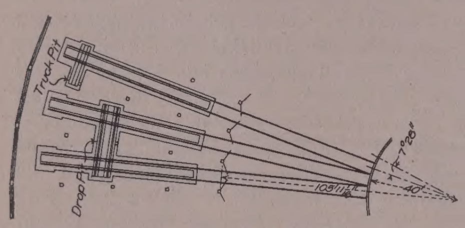
A Novel Means of Preventing the static interference of single-phase electrical operation with railway telegraph lines along the right-of-way has been applied on the recently electrified division of the Erie R. R. between Rochester and Mt. Morris, N. Y. In the application of a system to prevent the telegraph relays from chattering, it was found desirable to "pacify" the instrument by auxiliary devices and connections rather than to attempt to compensate for the electro-static and electromagnetic induction from the propulsion lines, and this is accomplished by using 150 ohm back-contact relays with 350 ohm shunts across their line terminals, each relay making a connection on its back contact at each opening, though an auxiliary circuit containing a 7 volt battery and 500 ohm resistance. The 350 ohm shunt is in the form of a non-inductive carbon stick resistance and is effective in offering an easier path for the electro-static than the relay magnets; but the resistance is low enough to render the relay's action noticeably sluggish in action. This sluggishness is compensated for by the insertion of the battery in the auxiliary circuit which, when the relay is open, throws additional battery onto the line and assists its relay in responding to the key at its home or any other station. The shunt resistance must, however, be adjusted at different locations on the line as the effect of the interference is greater near the battery and ground, and the resistance must be less.

The Roundhouse of the Lehigh & Hudson River Railway at Warwick, N. Y.

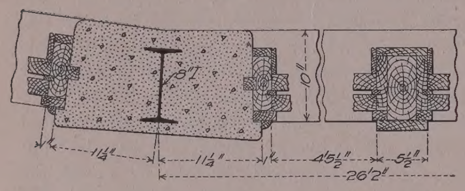
The new engine house at Warwick, N. Y., for the Lehigh & Hudson River Ry. Co., is of the usual shape with stalls for ten locomotives and is designed to provide for future extension as necessary. It is 95 ft. long radially and 261 ft. 8 in. wide at the outer or convex end. The center lines of the tracks make a uniform angle of 7 deg. 28 min. with each other and converge to the center of the 80-ft. turntable 105 ft. 11 1/16 in. from the inner or concave wall of the engine house. The construction is very simple and consists of a flat wooden roof supported on steel and concrete columns, and concrete walls. Both of the radial walls of the building have large window spaces and more than half of the area of the outer or convex wall is covered with windows, while a continuous line of windows 7 ft. deep occupies the full width of the inner or concave wall above the large doors. Over each of the stalls there is a radial monitor ventilator without windows. The usual steam, water and electric light installations are provided and a heating apparatus sufficient to maintain a temperature of 60 deg. in zero weather is installed in an adjacent fan house annex, equipped with a 78-in. Buffalo Forge Co. blast wheel operated by an 8 x 8-in. single vertical center crank direct-connected engine. Hot air is distributed through a system of underground ducts having a 20-in. tile pipe laid in alternate panels between the locomotive pits and furnished with two 12-in. outlets communicating with each pit.

An interesting feature of the construction is the special combination of steel, concrete and wood used in the main framework. There are in all 55 columns, from about 23 to 24 ft. apart in 11 radial rows, 13 ft. 9½ in. apart at one end and 26 ft. 2 in. apart at the other end. The two outer rows of columns are on the center lines of the end walls, and the end columns of the intermediate rows are in the curved inner and outer walls. All columns have concrete foundation piers carried down to a depth of about 4 ft. The columns in the convex wall are seated on the continuous footing of the latter. All columns are made with single full-length 8-in. vertical I-beams with pairs of horizontal cap and base angles riveted to their webs and flanges. They are enclosed in a solid rectangular mass of concrete with rounded corners in which is imbedded a reinforcement of four ½-in. round rods hooped with wire. The columns are knee-braced in four directions to the wooden rafters and purlins with 6 x 8-in. struts having both ends bevelled and secured by tie bolts. The lower end engages an angle iron seat riveted to the I-beam in the column and the upper end is toed into the rafter.

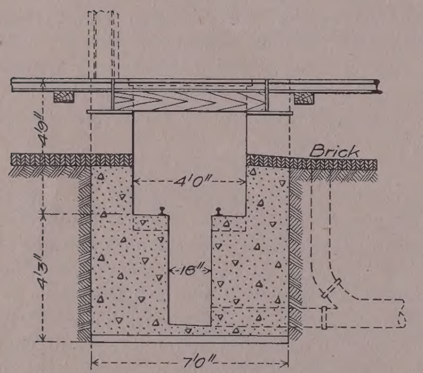
The 10 x 12-in. rafters have butt joints on the



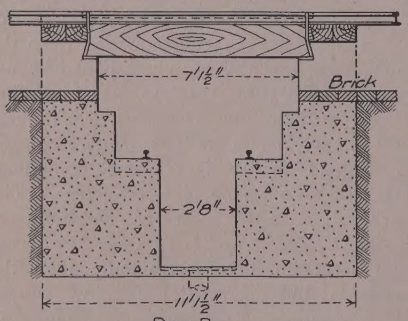
Tracks with Special Pit.



Wall Column and Pier.

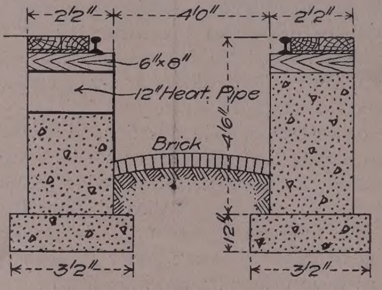


Truck Pit

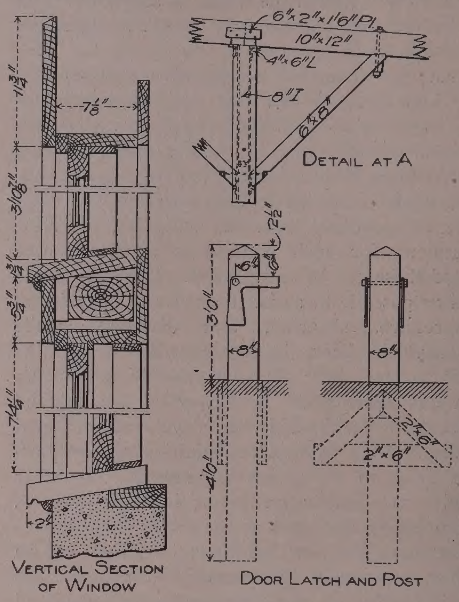


Drop Pit

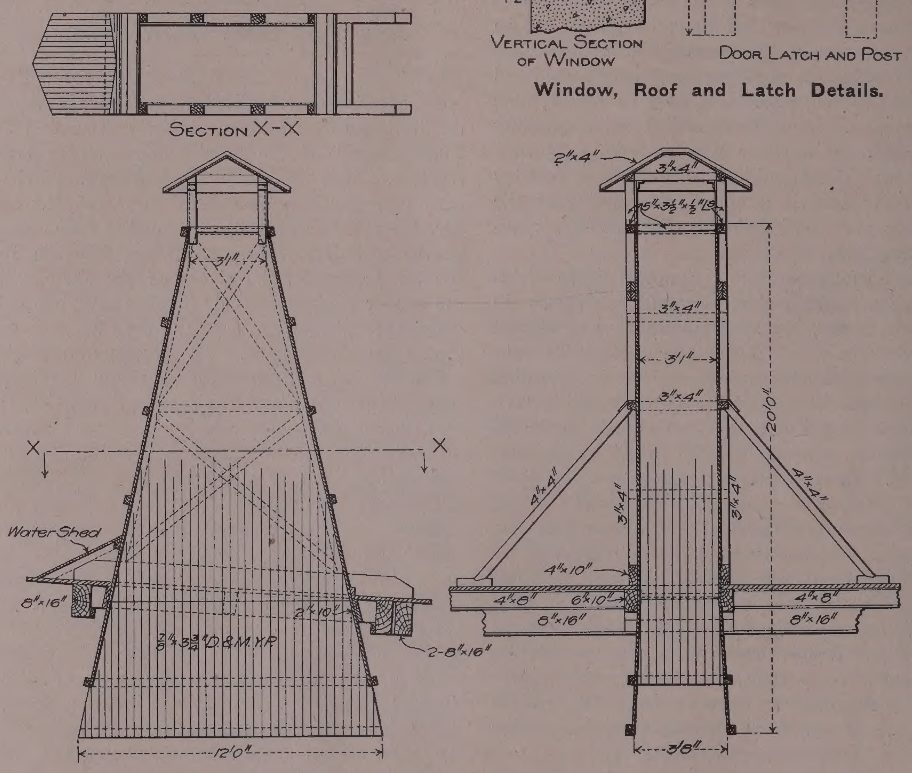
Cross Sections of Transverse Pits.



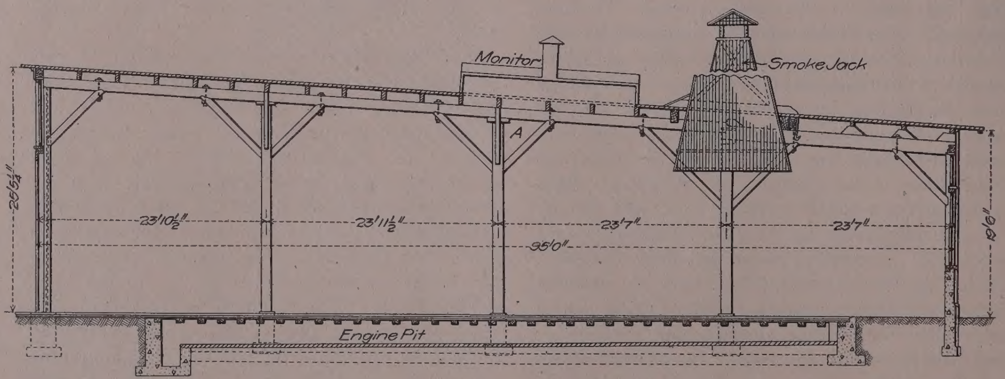
Main Pit.



Window, Roof and Latch Details.



Details of Wooden Smoke Jack.



Radial Section Through Pit.

center lines of the columns to which they are connected with lag screws through the cap angles. They are spliced with 6 x 2-in. fish plates and carry 4 x 12-in. purlins about 4 ft. apart, making butt joints on their center line. The purlins are covered with 2 x 6-in. boards water-proofed with asbestos roofing laid by the Franklin Mfg. Co., Franklin, Pa.

In order to provide for future extensions one of the radial walls of the building is of temporary construction made with a framework of 4 x 6-in. vertical wooden studs about 30 in. apart on centers secured at the feet to a 4 x 10-in. sill bolted to a concrete footing wall and covered with ordinary sheathing plank and siding. The permanent end wall is of expanded metal-concrete construction 2½-in. thick on a structural metal frame—all metal being encased in concrete so as not to be affected by smoke and gases. All of the other walls are of solid concrete 10 in. thick above the water table and are made without reinforcement. Below the water table, which is 15 in. above the top of rail, the thickness of the wall is 12 in. down to the concrete footing 20 in. wide and 12 in. deep, with its upper surface 3 ft. below the top of rail.

Interior of Roundhouse, Showing Smoke Jacks.

The locomotive doors, 12 ft. 4 in. wide and 17 ft. high, are each made with two leaves hinged directly to the concrete-steel columns. They are 1¾ in. thick, sheathed with 1⅛ x 4-in. diagonal boards, and each has three special 3 x ½-in. strap hinges extending across the full width of the door and engaging vertical pivots forged on the ends of 1-in. horizontal steel bars which extend through the columns and are screwed tightly against washers at the rear end. Long 8 x 8-in. vertical posts are set in the ground between the doors outside the building and are provided with pairs of automatic gravity latches to engage the doors and hold them in open position. The door and window frames are carefully fitted into the concrete wall as indicated in the detail.

Over each stall there is a tapered wooden smoke jack of special construction which is standard for the Erie R. R. It has horizontal dimensions of 3 ft. 8 in. by 12 ft. at the bottom and is about 23 ft. high over all. Care is taken to keep all the framework outside and it is thoroughly braced and the interior is painted with "Muralo" fireproof paint and sanded, the sand being found to promote the accumulation and retention of soot, which forms a very effective insulation. All other interior work, except window frames, is painted with the fireproof paint. All exterior wood work and window frames inside are given three coats of Chilton dark green paint No. 102, trimmed with Indian red, No. 61, the successive coats differing slightly in color. All concrete surfaces are left natural and unpainted.

In the center of each track there is provided a pit 70 ft. long, 4 ft. wide and 3 ft. deep, with concrete walls and bottom. The tops of the side walls are covered with crossed layers of solid pine timber to which the rails of a standard gauge track are spiked, and it also affords jacks to lift the locomotive and tenders. One pair of tracks is provided near the outer end with drop pits connecting them transversely as shown in the partial plan diagram and affording an opportunity for the driving wheels to be dropped down from the locomotive frame and rolled across clear of the locomotive. Another track is provided with a truck pit, similarly arranged to facilitate the removal of the locomotive trucks.

The engine house contains 30,000 lb. of structural steel, and was erected in less than three months after the contract was awarded.

All foundation and pit work to the floor line was done by the railway company's forces under Mr. J. E. Barrett, superintendent of tracks, bridges and buildings.

The improvement was under the direction of Mr. Morris Rutherford, vice-president and general manager, and the building was designed and specified by Mr. Mason R. Strong, consulting engineer, 7 Wall St., New York City. The general contract was executed by Welch Bros., Warwick, N. Y.

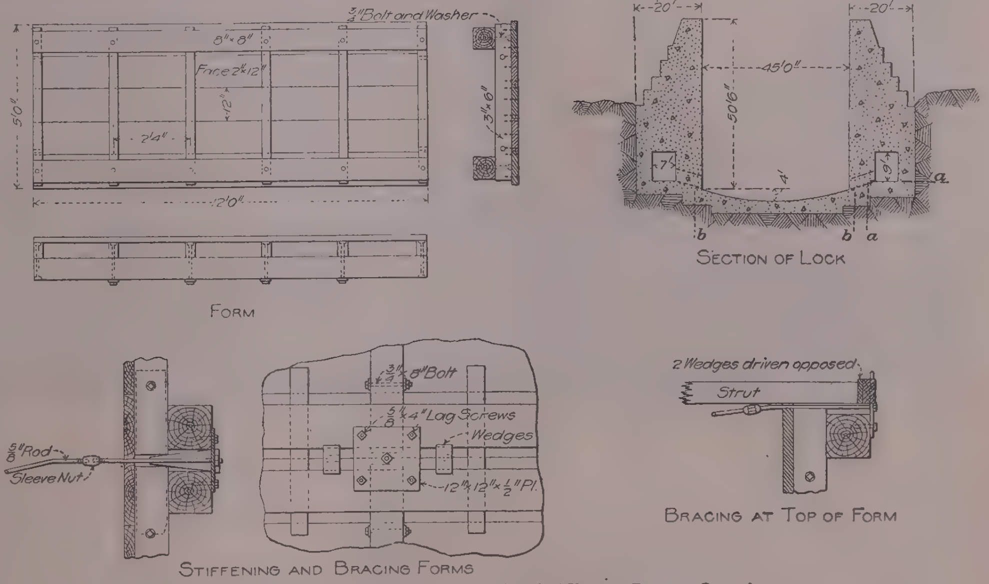
Construction of Lock 3, Erie Barge Canal.

By Oscar Hasbrouck, C. E.

Lock 3 is a good example of the general type of the miter locks used on the Barge Canal. It is situated at Waterford, N. Y., and is one of the six locks, including the lock at the Troy dam, which constitutes the lift between the Hudson and Mohawk Rivers against the eighteen locks of the present Erie Canal. It has the characteristic dimensions of 45 ft. between the face of walls, 328 ft. between hollow quoins and 12 ft. of water on the miter sill, and it contains 31,000 cu. yd. of concrete. The difference in elevation between miter sills, or the lift, is 34.5 ft.

The water is fed into the lock by the main culvert well, which is located just ahead of the upper gate; from this it is led off into two culverts which run the length of both lock walls, having their intake above the upper gate and outlet below the lower gate. At the end of each of the culverts there are valves for filling and emptying the lock. From each culvert in the chamber walls there are fourteen cast-iron port pipes 3 ft. in diameter, spaced 19.5 ft. apart, through which the water finds an inlet and outlet from the main chamber. There are also other appurtenances, such as line hooks and ladders in the walls and capstans and snubbing posts on the lock walls.

The concrete is furnished by a Hains mixer situated about 500 ft. from the lock and transported by three trains of four cars each in Stuebner bottom-dump buckets, two to the car, to the site of the lock, one train being left in the lock. The mixture is a 1 :2½ :5, and is mixed in six-bag batches, the average run for the day being 250 batches. It is then hoisted into place by derricks, three being able to take care of the total output though there are five in all, the others being needed to hoist forms and other materials when not in use for concrete. They are supplied with steam from a central boiler plant.



Form

Section of Lock

Stiffening and Bracing Forms

Bracing at Top of Form

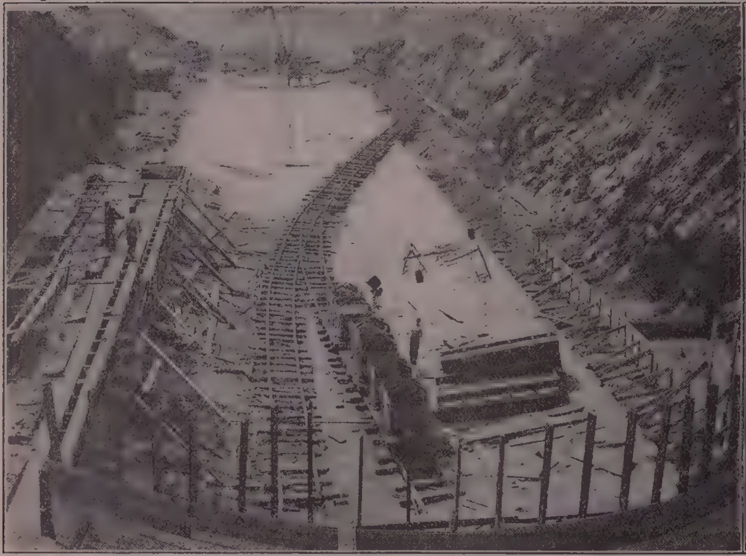
Details of Forms Used at Lock Three, Barge Canal.

The floor of the lock was first constructed along the lines *b b* shown in the general section; this was laid in 16 ft. sections by setting templates to grade. The track was then laid over this and the side walls commenced along the lines *a a*, the grade being set to the floor of the culvert. As soon as the work had progressed sufficiently, the port pipes were set and concreted in. At the same time the side walls were being constructed, the breast wall and head wall were carried up. The side walls were built up in 48-ft. sections, a tarred expansion joint being provided at the end of each. In all cases where a floor was to be finished off, the concrete was brought to that elevation and the part in question finished before work was resumed.

The culvert linings to which the valves are fastened were set by lowering the bottom plate in a soft bed of concrete and grout, and tamping them until they were thoroughly imbedded and rested on their flanges on blocks set to grade. When these had sufficiently set, the side plates were bolted on.

Cement House, Mixer Plant and Trestle.

Method of Setting Miter Sill.



View of Invert from Upper End.

View from East Side of Cut.

The miter sills were set to grade and line by resting them on small rectangular boxes, and the anchorages suspended from them. They were then concreted in, after which the boxes were removed and the holes filled.

The anchorages for the gates were supported on chairs at the right elevation and line before concreting began, as monolithic construction was required within certain limits. All other imbedded materials were suspended in position before their grade was reached.

The panel forms, which are the unique feature of the work, consist of planking nailed to studs, which are backed by two heavy timbers. The general size is 5 x 12 ft., though different sizes were used according to their purpose. The standard panel consisted of five 2 x 12 in. planking 12 ft. long nailed to six 3 x 6 in. studs 4 ft. 10 in. long, and these in turn bolted to 8 x 8-in. timbers 12-ft. long. The bolts were countersunk on the face of the studs and at the back on each end.

When in use these were set one on each other and held in place by wedges driven behind the 8 x 8-in. pieces and between them. They were also supported by being bolted to each other by two bolts and held in line by a 12 x 12 x ½-in. steel plate at the corners, each plate covering four panels and held to them by four lag screws. Through the center of each plate there ran a rod having a sleeve nut at least 6 in. inside the form, at the back, it being bent down to the level of the panel below where it was fastened to the back form, an iron rod driven into the concrete, or a post imbedded in the concrete, according to whether it had a rock backing or not. The top was held to line by a wooden strut braced at the back against the rock, an imbedded post, or back form, and at the front against the upper half of the iron plate.

The panels were brought into line from a 2-ft. offset line with a transit, by either tightening the nut on the front of the plate or driving wedges, opposed to each other when necessary, between the end of the strut and the plate.

All curved surfaces were constructed by nailing ⅞-in. ship lap over templates and holding it in place by rods and struts similar to the above.

The above method has worked very satisfactorily, no giving away of forms having been experienced. It is economical and is to be recommended for use in heavy construction.

The contracting is being done by the Ferguson Contracting Co. of New York, and the engineering by the Department of State Engineer and Surveyor.

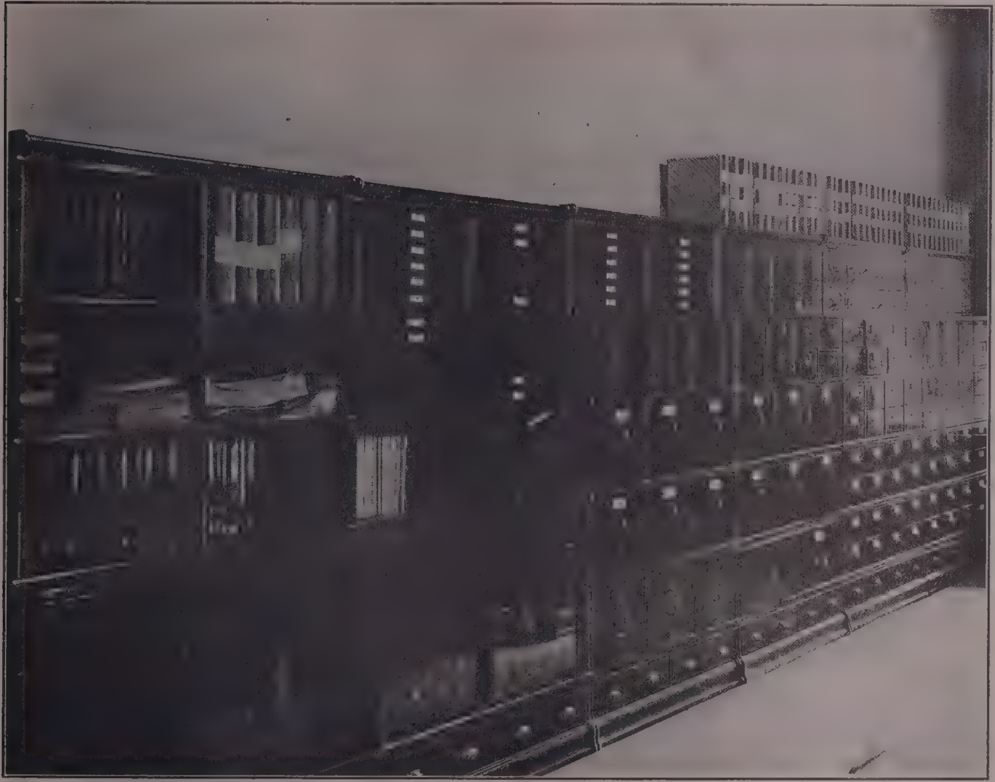
Hydraulic Sluicing with Jet Elevators.

Hydraulic slucing is often accompanied in New Zealand by the use of elevators by which the sluiced material is raised to considerable heights. These elevators, according to "Engineering," London, from which these notes have been taken, take the form of injectors, a powerful jet of water being directed upwards inside a tube or jacket into which the material is fed just above the jet. At one mine at which water is available under a head of 380 ft. two elevators are used and in two lifts the material is raised 140 ft. At another mine where the jet has a pressure due to a head of 400 ft. the material is lifted 64 ft. in one lift. Where such pressures are not readily available various expedients are necessary. On the Lower Tuapeka River the water has been dammed up to a height of 30 ft. and under this head drives a horizontal turbine which in turn drives a set of centrifugal pumps in series. These pumps give a discharge sufficient for working five heads on a terrace 150 ft. above the river level. The waste water finds its way back to the river

An Extra Profit Sharing Dividend of $65.40 has been declared for the employees of the United States Steel Corporation who subscribed for preferred stock in 1903. This is in addition to the regular dividend of 7 per cent. and a regular bonus of 5 per cent. which they have received yearly. The total payments in five years have been $125.40 a share, which, deducting the cost, $82.50, leaves a net profit of $42.90 a share. The extra dividend is payable only once, and on stock which has been held continuously by an employee for five years.

A System of Filing Engineering Notes and Records.

A modern system of filing all office records, field notes and correspondence has been developed recently in the office of Mr. Lewis C. Kelsey, city engineer of Salt Lake City, Utah. The organization of the engineering department of that city is under the general supervision of the city engineer, who has a principal assistant and several other assistants, each of the latter being in charge of a division of the department. All pavement and sidewalk construction is under the direction of an assistant engineer of streets. The construction and maintenance of the sewerage system are carried on under an assistant engineer of sewers, who has a foreman in immediate charge of operation. An assistant engineer is in charge of the water-works construction; all electrical wiring and installations are subject to the approval of an assistant engineer, and the surveys of private property, which are largely made by the field parties of the municipal organization, are also under another assistant engineer. A chief clerk has supervision of the clerical forces, and the drafting room is in charge of a chief draftsman; a chief computer, with a force distinct from that of the drafting room, is also included in the organization. The volume of work handled by this organization has been materially greater in the past two years than ever before, as a total expenditure of $865,000 was made in 1906, and of $1,250,000 in 1907. At the same time, plans have been prepared for a large volume of additional improvements to be made during the ensuing year, or as rapidly as funds are available.



A Section of the Filing Drawers and Compartments.

The unusual amount of computations, drafting, surveys and field work rendered necessary by the construction which has been carried on, or that is contemplated, has made imperative the provision of some simple, accurate system of record and filing. After considerable investigation of systems already in use in the engineering departments of other cities and of various private interests, the decision was made to depart from usual practice and adapt the loose-leaf and card-index method to all branches of the organization, including the books of the field parties, the inspectors and so forth. A considerable number of original forms were thus necessarily required, since so far as could be determined no attempt had been made to carry all records of an engineering organization on loose leaves as completely as was proposed.

A large fireproof vault with exterior lighting was available in the offices of the department and was fitted with drawers and compartments providing sufficient filing space. Metal furniture was used for this purpose, the compartments being made of proper size to fit the various loose-leaf forms. A metal bookcase for bound loose leaves and a row of metal drawers for drawings were also provided. All of the furniture was built in sections arranged so additional units may be provided as is necessary.

The various accounts of the department are each given a key number, which is used by all branches of the organization, including the auditing and clerical forces. A sheet giving the various accounts and their number is posted on the wall back of the row of filing compartments, in full view from all parts of the vault. The different compartments and drawers containing records pertaining to an account each bear the key number of that account. Each individual account under the general account is also given a a letter by which it can be identified readily. The various loose leaves and cards bearing data pertaining to that individual account each bear the general number and also the letter, so any of these leaves and cards may be quickly selected from the compartment or drawer in which they are filed. In order to further simplify the identification and filing of the data pertaining to the different general accounts, all of the stationery for each of the latter is of a distinct color. Water-works stationery is on a pale blue paper, street records are on pink, sewers are on light green, sidewalks are on light brown, private surveys are on lemon yellow, and miscellaneous accounts are on white. These colors are strongly contrasted, so the isolation of the records of a general account is easily obtained, and, at the same time, a searcher can determine at a glance whether he is in the proper file.

This general scheme of the system has been modified in details to suit different conditions presented by various subsidiary branches of the general accounts. These different details may be explained best by taking up the method of application to one general account, the water-works department. This account has two general filing numbers, 3 and 4, because of the volume of work handled under it, one number being for maintenance and the other for construction. All correspondence and estimates regarding the branches of the account are filed daily in a drawer of proper size. A cardboard folder bearing the general number and the number of the particular project under that account to which the correspondence relates is provided in the drawers. For instance, grades and lines for hydrants and pipes are under the number 3-A; and water investigations are under the number 4-B-2, the secondary figure being used after all the letters of the alphabet have been exhausted.

The preliminary estimates are prepared in the computing department on titled sheets of standard size, both ruled and unruled sheets for this purpose being provided. The unruled sheets have printed in the upper right-hand corner blanks for the names of the computer and the checker, the number of the project, the date, the sheet number and the number of sheets. The ruled sheets have the same blanks and are printed with suitable spacing for columns of figures. The preliminary estimates used to accompany notices to the public of intention to make improvements are also made on standard forms, three of which are provided, one for the original, one for a stenographer's copy, and the third to attach to the notice. The provision of these standard forms, all of which bear the number of the project, has been found to greatly simplify the filing system.

After a copy has been completed all of the correspondence and estimates pertaining to it are bound in a special folder provided for the purpose. The bound volumes are placed in cases, which are also numbered so any old records are at once available.

The field notes of the surveying parties having to do with the water-works division are made and preserved on loose-leaf notes, in fact, all the field notes of the entire department are made on loose leaves. The notes concerning any project can thus all be filed together whether they cover two pages, or fifty. The great difficulty of locating in bound field books the data pertaining to any project is, therefore, entirely avoided. At the same time, the notes for each project being entirely separate from those for all other projects, they can be used at any time, without interfering with the use of other notes, as is occassioned with the usual bound books of notes.

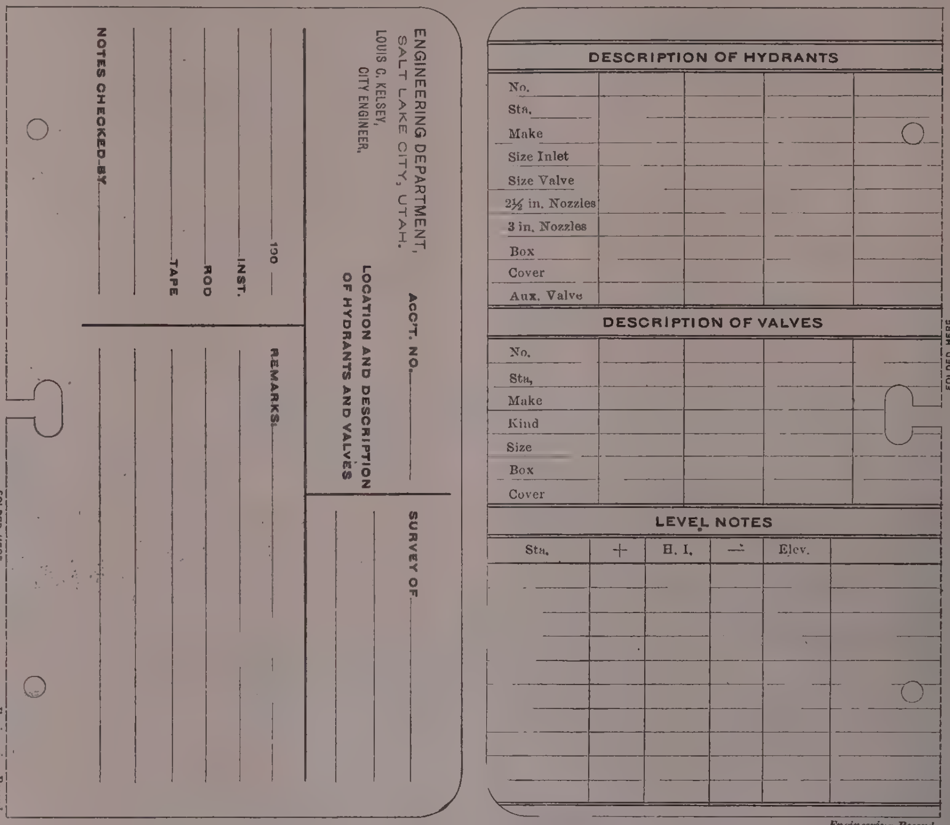
The objections to this system which might appear to exist are believed to be overcome by the details that have been developed. The loose leaves for the notes are made about the same size as the leaves of the standard bound field books commonly used, two leaves being made together in a folder. On the top of the front page of this folder is printed the title of the general nature of the work, a blank for the account number, and one for a brief description of the project being surveyed. Below these are blanks for the names of the field party and of the office man who checks the computations, with space for remarks concerning any special features of the work done.

The front page of a two-leaf folder for hydrant and valve surveys is shown in an accompanying illustration, and the second page of the same folder, on which blanks for a description of the hydrant and valves are printed, is shown in another illustration. In one standard form for this purpose, the third and fourth pages are left blank for sketches and so forth, while another form has the frontage of two city blocks and the intersecting street lines printed on the third page, so little freehand sketching is required.

Blank leaves for notes or other classes of work are made up in the same general way. All of these leaves are punched close to the left-hand margin so they can be fastened in loose-leaf books for use in the field, and also so they can be placed in filing drawers afterwards. These drawers bear the number of the general account to facilitate ready location of any particular notes, the leaves being filed consecutively according to the secondary numbers. The two-leaf folders are made instead of providing single leaves, because almost any survey requires at least two pages and because the two-leaf folder is more easily handled than a single leaf.

The various estimates made during the progress of construction under a contract are also prepared in the office on single loose leaves of convenient size. These originals of the estimates are properly labeled with the general account and secondary number so they can be filed properly and will be found easily. The drawers for these estimates are separate and distinct, but are close together so that all data pertaining to any project is filed conveniently. The progress and final estimate sheets are afterward bound with the preliminary estimates, correspondence and so forth, relating to any particular project, but the field notes are bound separately.

Inspectors reports are made daily in an ordinary bound note-book, which is kept in the field until the end of the month and then returned to the office to be filed. These reports are copied daily on loose-leaf sheets by an inspector-in-chief, who makes the rounds of the different pieces of construction. The loose-leaf copies are then filed under their proper general and secondary numbers, so they can be found at once, without referring to the bound books, which are preserved merely as a matter of original record. The second and third pages of a two-leaf folder for filing inspectors' notes on water main extensions are shown in an accompanying illustration and are typical of the type used. The first page of this folder contains blanks to give the location and number of the extension, and space for remarks concerning any special features connected with the progress of the work. The fourth page is a blank.



ENGINEERING DEPARTMENT,
SALT LAKE CITY, UTAH.
LOUIS C. KELSEY,
CITY ENGINEER.

ACC'T. NO.____

LOCATION AND DESCRIPTION OF HYDRANTS AND VALVES

SURVEY OF____

190____

INST.____

ROD____

TAPE____

NOTES CHECKED BY____

REMARKS____

FOLDED HERE

DESCRIPTION OF HYDRANTS

No.				
Sta.				
Make				
Size Inlet				
Size Valve				
2½ in. Nozzles				
3 in. Nozzles				
Box				
Cover				
Aux. Valve				

DESCRIPTION OF VALVES

No.				
Sta.				
Make				
Kind				
Size				
Box				
Cover				

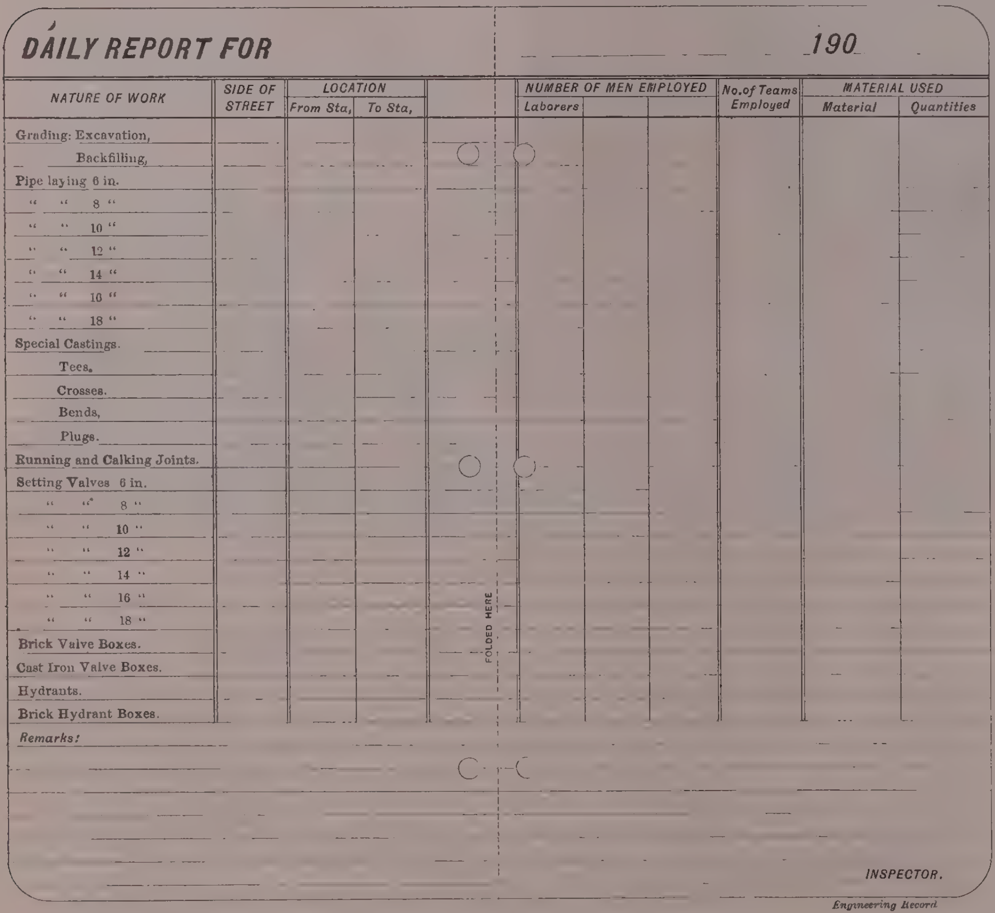
LEVEL NOTES

Sta.	+	H. I.	−	Elev.

FOLDED HERE

Engineering Record

Front and Second Pages of Two-Leaf Folder for Hydrant and Valve Surveys.



DAILY REPORT FOR ____ 190__

NATURE OF WORK	SIDE OF STREET	LOCATION			NUMBER OF MEN EMPLOYED			No. of Teams Employed	MATERIAL USED	
		From Sta,	To Sta,		Laborers				Material	Quantities
Grading: Excavation,										
Backfilling,										
Pipe laying 6 in.										
" " 8 "										
" " 10 "										
" " 12 "										
" " 14 "										
" " 16 "										
" " 18 "										
Special Castings.										
Tees.										
Crosses.										
Bends,										
Plugs.										
Running and Calking Joints.										
Setting Valves 6 in.										
" " 8 "										
" " 10 "										
" " 12 "										
" " 14 "										
" " 16 "										
" " 18 "										
Brick Valve Boxes.										
Cast Iron Valve Boxes.										
Hydrants.										
Brick Hydrant Boxes.										

Remarks:

FOLDED HERE

INSPECTOR.

Engineering Record

Inside Pages of Two-Leaf Folder for Inspectors' Use.

The assistant engineer of each division of the department makes a daily report, on a blank suitable for filing, concerning each of the projects in progress under his direction. These reports take the place of diaries frequently kept in many engineering organizations. They have the very great advantage over such diaries, however, that all records of special note concerning any one piece of construction are immediately available from the files and may be used without interfering with the simultaneous use of similar data in regard to the other projects.

The office of the city engineer of Salt Lake City is now an office of record so that practically all surveys of private property are made by the municipal engineering organization. A resurvey of the entire city was authorized in 1890, providing for permanent monuments, the location of a base line for each division of the city and so forth. Much of this resurvey has been made and is platted in bound books in the city engineer's office. All surveys of private property are based on the new monuments, the field notes being taken on two-leaf folders similar to those used for other work. The orders for these surveys are each recorded in a loose-leaf order book also containing two-leaf folders. On the first, second and fourth pages of these book folders are blanks for the order number, the lot, date of survey, owner's name, and the field note file numbers. The third page is a printed sketch of one of the standard sized blocks into which the city is divided, with monuments shown at the intersecting street corners and a blank at the top for the block number.

The original survey sheets were made up in the drafting room and each of the several plats of the city bound separately. The private surveys are recorded on these bound plats and are also entered on the loose-leaf folder for the block in which the survey is made. Later these loose-leaf folders can be bound as the property in any one block is all surveyed. Meanwhile, the records are indexed in a file of loose-leaf sheets, which sheets give the name of the owner, the number of the lot, the number of the block and the plat, and also the section number, and the page of the book in which the record is to be found.

Various other records of the department are kept by the card-index or loose-leaf system. For instance, permits for sewer connections are recorded separately on cards which are indexed according to streets. Each card has a blank for the number of the connection, and one for the location of the connection by street number. Blanks for the names of the street, the owner, the plumber, date of permit, and remarks are also provided. The connections are also platted on separate sheets of tracing cloth, the streets being platted to different scales according to the frequency of connections. Prints from these tracings are bound and filed. The card-index system permits the general conditions regarding the sewer connections on a street to be determined by a glance at the files, while the detail information, if desired, can be obtained from the platting on the sheets.

The cases of drawers for filing the original tracings of the department are made 2 in. deep, and large enough in plan to take the maximum-size drawing. The cases are divided into vertical sections of drawers for convenience in numbering the tracings. Each of the tracings bears a whole number, which is the total number of drawings made to date; it also bears a section number and a drawer number corresponding to the number of the section and drawer in which the tracing is filed; and a fourth number which gives the location of the tracing in the drawer. Each tracing is listed on a separate card giving these various numbers, the date the tracing was finished and the scale to which it was made. These cards are filed according to the general account and extension numbers. Any tracing can thus be located at once from this index. A completely equipped laboratory for testing cement, asphalt and other construction materials is maintained as a part of the engineering organization of the city. All the reports of tests made in this laboratory are recorded on loose-leaf blanks which are readily removed from the filing cases for reference.

The filing system of the department is kept up to date by two assistants working in the vault and by an occasional small amount of help from different members of the staff. The expense of maintaining it has been very nominal, while the results obtained have enabled a great saving in time to be made, besides the increasing facility for future reference as the records become more voluminous. All drawings, profiles, notes and so forth taken out of the files are charged on a slate, at the side of the door of the vault, to the man who receives them, the charge being removed when the records are returned. This simple method replaced a card file system and with a proper amount of discipline has been found to be much more effective than the earlier system.

On account of the vast amount of lettering necessary to title the large volume of tracings and the filing cases, a small printing outfit has been installed. The outfit comprises a 10 x 15-in. Gordon press and 45 founts of type, with everything necessary to successfully operate at a decided advantage over free-hand lettering. The department is also considering the advisability of adding to this equipment somewhat, in order that the entire printing for the office, including forms and so forth, may be done under the direction of the department.

As a matter of record and protection in case of legal suits the department operates a fully-equipped photographic outfit. Progress photographs are made of every stage of the various improvements. The usefulness of these photographs as a record cannot be disputed, while in legal proceedings they are specially valuable. The expense of operating this branch of the department is exceedingly small in comparison with the saving that results in suits that may have otherwise been lost. On the result of a single case the department has been enabled to pay the expenses of this branch for a year. At the present time there is on record 1,500 negatives conveniently indexed and filed.

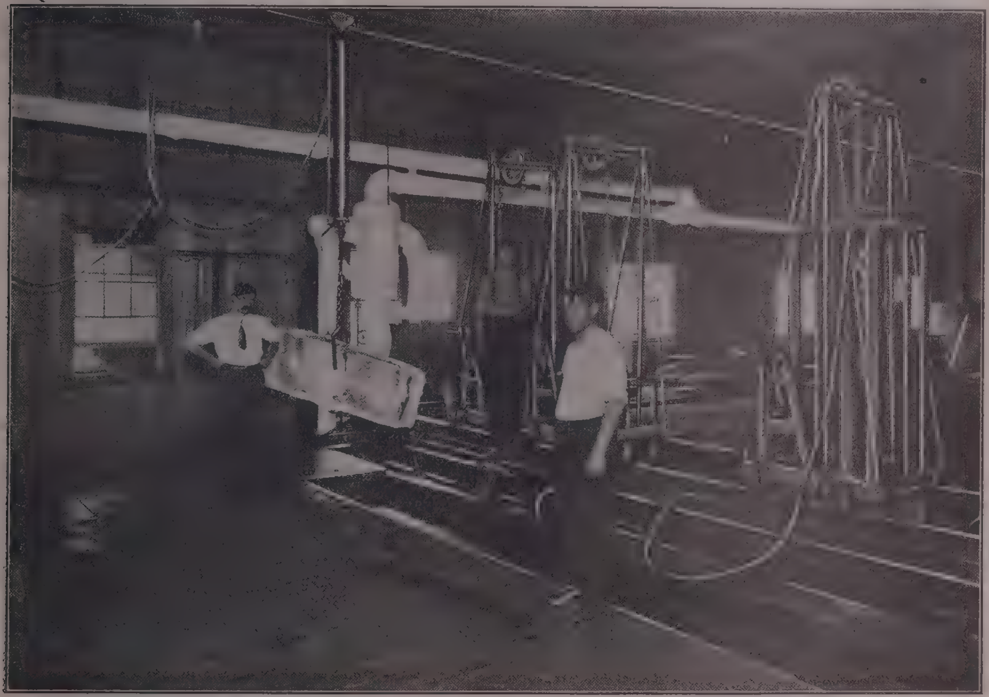
The information on which these notes were based was furnished by Mr. Lewis C. Kelsey, city engineer of Salt Lake City, under whose direction the recording system was developed.

The Block Signal System of the Illinois Central R. R. on 42 miles of the double track division between Kensington and Kankakee, Ill., has recently been reconstructed, the blocks being shortened to accommodate the greatly increased traffic. In the new system both home and distant signals are located on the same pole, and the distant signals at all interlocking plants are now power-operated. The signal circuits are operated by portable storage batteries sent to a repair station at Homewood for charging.

Mechanical Plant of the Worcester Cold Storage & Warehouse Company.

By Howard S. Knowlton.

One of the most modern refrigerating installations now operating in Massachusetts is the plant of the Worcester Cold Storage & Warehouse Co., which was completed for commercial service about a year and a half ago. About six months after the plant began operation an ice-manufacturing equipment was installed, and during the past year both classes of service have been supplied. Artificial ice is sold by the company in Worcester at 30 cents per 100 lb., which is an advance of about 5 cents above the price of natural ice. To the company's customers the difference in price for ice is readily absorbed by the better quality of the artificial product. The cooling service of the plant covers the usual cold storage of provisions, furs, etc. The consulting engineer of the plant was Mr. Walter L. Hill, of the Eastern Cold Storage Co., Boston, who is general manager of both companies. The plant consists of a six-story warehouse with a separate two-story and basement power house. The building is of the mill type, with brick outside walls and masonry foundations. The warehouse is 85 ft. square and the power house is about 50 x 85 ft. There is a brick stack 5 ft. in diameter and 100 ft. high. Two side tracks of the Boston & Albany R.R. enter the company's property.



Removing Block of Ice from Freezing Tank, Worcester Cold Storage & Warehouse Company.

At present twelve rooms are in use in the warehouse. The coldest service is given in the two upper stories, which are piped in the ratio of 1 sq. ft. of pipe surface per 7 cu. ft. of room volume. The lower floors are piped in the ratio of 1 to 14. The direct expansion ammonia system is used. The outer wall of the warehouse is 24 in. thick, and coated with carbon paint on the inside. Next comes a ⅞-in. strapping with an attached layer of paper, followed by 12 courses of matched boarding and paper with strapping and an air space between each course. Inside these are two thicknesses of boarding, which form the inner wall of the refrigerating room. The construction of partitions is in general similar to that of the walls. The flooring consists of one course of floor boards, two courses of paper, one of plank, 12 in. of shavings between joists, a course of sheathing, two courses of paper and a final bottom course of sheathing.

Coal is shovelled from the cars on one of the spur tracks into a hand-operated bucket system which runs on a single overhead rail into the boiler room. A set of scales is included in the travel of the bucket. From the bucket the coal is dumped into a bin in the boiler room, which has a capacity of 250 tons. Outside the boiler room is also a storage capacity of the same amount.

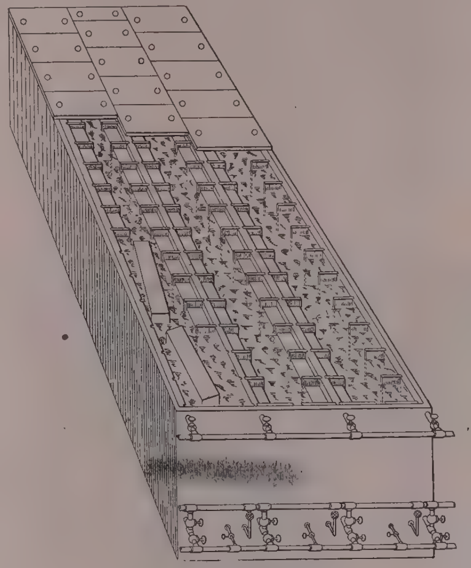
The boiler room contains two 150-h.-p. Stewart horizontal return tubular boilers built for 125 lb. steam pressure, and operated at 100 lb. Each shell is 6 ft. in diameter and 18 ft. long, with a grate 5 ft. 6 in. by 6 ft. The coal is fired by hand, and city water is used for boiler-feeding. The water supply enters the basement of the power plant by a 2-in. line branching by pipes of this size to two feed pumps, each of the latter being a Warren 5¾ x 5 x 5 in. duplex plunger pump. Each pump acts as a bypass to the other. From the two pumps a 2-in. line goes to the meter, and thence through a Jacobs vertical closed feed-water heater to a pair of 1½-in. lines leading one to each boiler. If desired, the boilers can be fed directly from the meter, in case anything happens to the heater. Each boiler is provided with a 4-in. Consolidated nickel seated safety valve. A 2-in. blow-off connection at each boiler leads into a 4-in. main discharge line leading into the atmosphere. No sump pits were necessary in the plant.

Steam is taken from the rear of each boiler by a 6-in. long twin elbow connecting with a 10-in. header which traverses the boiler room longitudinally, passing into the machinery room of the plant through a fire wall separating the two. The power plant equipment is arranged in general as follows: The compressors of the ammonia system are steam driven and located in the machinery room, at the ground level. In this room is also a small electric generator for lighting service. The auxiliary equipment is mainly located in the machinery room basement, which is at the same grade as the boiler room floor. In an extension of the power plant the ice-making tanks are installed. The condensing apparatus of the ammonia system is located on the roof of the machinery room. The main header in the latter room is about 12 ft. above the floor.

The refrigerating equipment consists of two vertical duplex 12¼ x 27 in. De La Vergne compressors direct-driven by two horizontal 24 x 27-in. steam cylinders. Each machine has a capacity of 75 tons refrigerating effect in 24 hours, and a normal speed of 42 r. p. m. Oil injection is provided in the ammonia cylinders, which are not water jacketed. Both units are mounted on concrete foundations which extend through the basement into the ground below. Temperatures from zero to 10° Fah. are readily maintained in the freezing floors of the warehouse by this equipment.

The steam header from the boiler room enters the engine room at right angles to the wall and is connected with a 10-in. horizontal main parallel to the wall in the latter room. The compressor steam cylinders are supplied by an 8-in. line branching into two 6-in. line steam pipes, connected each to one cylinder. From the main in the engine room a 1-in. line leads into the warehouse office, which is steam heated, through a reducing valve. The main decreases in diameter from 10 to 3 in., branches being taken for the auxiliaries at various points. The boiler feed pumps receive steam through ¾-in. leads connecting with the header by a 1-in. line; the lighting engine, which is a 7 x 6-in. vertical Forbes unit driving a 125-volt Crocker-Wheeler direct-current generator, receives steam through a 1½-in. connection from the engine-room header; and a 3-in. line is carried down into the basement for the auxiliaries. The latter include a 14 x 8½ x 18-in. duplex Warren elevator pump, with 2½-in. steam supply; a 12 x 36-in. deep well pump supplied by a 1½-in. steam line; a 6 x 6 x 6-in. simple air compressor served by a 1½-in. line; and a 6 x 8-in. York vertical engine driving a 14-in. rotary fan which agitates the water in the ice tank by air currents. The elevator pump takes care of the hoisting service in the warehouse, which is handled by two hydraulic elevators. The air compressor operates a hoist in the ice-making room, used mainly for lifting ice blocks out of the tanks. It operates at 80 lb. pressure, and delivers by a 2-in. line into a 5 x 12-ft. vertical tank in the basement, which connects with the ice tank by a 1¼-in. pipe. The deep well pump takes care of the artesian well supply, which is used in the cooling of the oil and ammonia condenser coils on the roof.

The electric generator supplies power to about 23 h.-p. in motors in a 4-story factory building owned by the company near the site of the ice plant. This factory is heated by exhaust steam from the cold storage power plant, and provision is also made for a 1-in. line steam supply in case there is not enough exhaust steam.



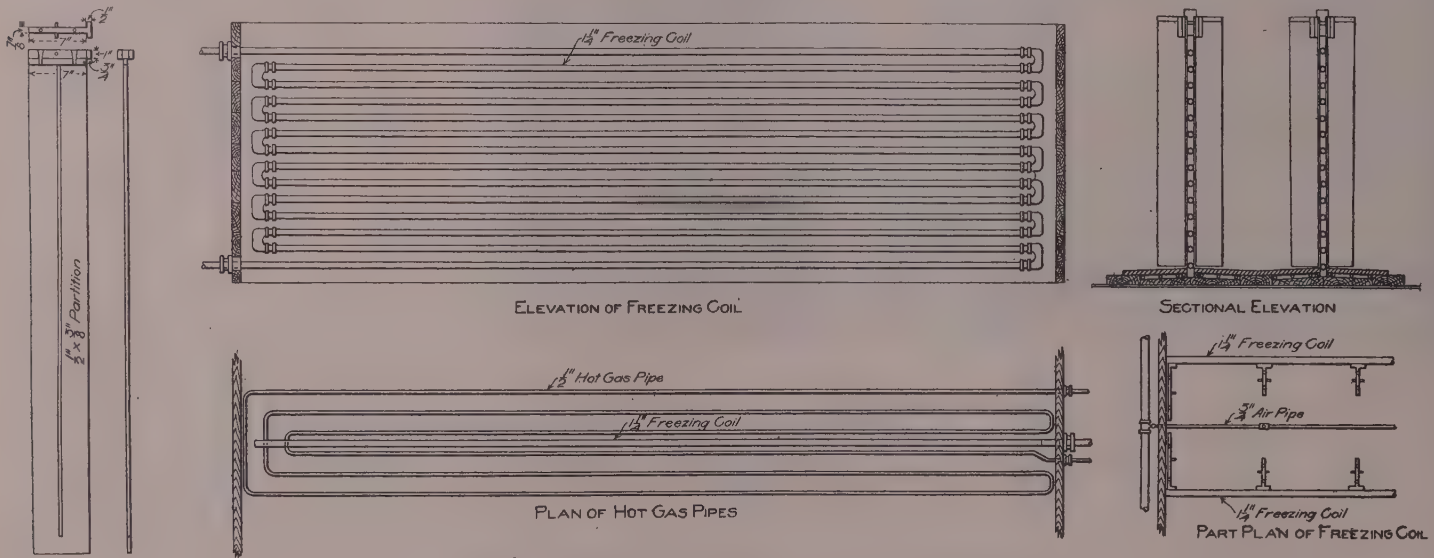
Ice Tank Arrangement.

The exhaust system provides for the collection of all the discharged steam in a 10-in. trunk line which passes through the feed water heater and terminates in a 10-in. Paterson head above the roof level. The basement exhausts are collected in a 5-in. line, with the exception of the deep well pump, which delivers through a 2-in. pipe to the 10-in. main.

From the ammonia cylinders the compressed gas is carried by four 2½-in. pipes into a 4-in. header, which connects with a hot-liquor tank in the engine room. From this tank a 4-in. line is carried up to the condensing coils on the roof. There are thirteen stands of coils made up of 2-in. pipe, twelve stands being used by the ammonia system and one stand for oil cooling. The circulating water from the deep well is pumped to the roof coils through a 4-in. line. The oil is separated from the ammonia at the roof level by Hill-Ray separators. The temperature of the circulating water ordinarily runs about 53° Fahr. and the highest reached during the past summer was 87°. The separated oil is discharged into the sewer through a 6-in. pipe. A storage tank 16 ft. long and 18 in. in diameter is mounted on the roof to serve as an ammonia reservoir. A liquid ammonia tank is also mounted in the engine room in series with a 2-in. line connecting with the ice tank. From the ice tank and the warehouse 4-in. double-return pipes are provided to bring back the hot gas from the cooling coils to the compressors. The ammonia supply to the warehouse is brought into the third story by a 2-in. pipe which crosses the space between the buildings above ground, and which connects at the power house end with the ammonia line from the condensing apparatus. Drips from pumps, compressor steam cylinders, and the exhaust head are discharged into the boiler blow-off line upon waste land.

The ice plant is installed in a tank 71 ft. 9 in. long, 28 ft. 6 in. wide, and 63 in. deep. There are 26 sections of 1¼-in. pipe in each coil, the pipes being spaced 4 in. apart on centers. The capacity of the plant as at first installed was 25 tons of ice in 24 hours, and the ice cutting was performed by a standard Pusey ice cutter. A new arrangement, patented by Mr. Hill and Mr. Ray, of the Eastern Cold Storage & Warehouse Co., has recently been placed in service at the west end of the ice tank, and by this device the capacity of the tanks equipped with it has been increased from 40 to 50 per cent. Ice has been frozen to a total thickness of 23 inches in 3 days with this equipment, which is illustrated in the accompanying drawings. The old steam-cutting apparatus necessitates losing a part of the ice through melting as it is taken out of the tanks. By the new arrangement steam is turned into the ammonia coils and hot water is allowed to run down through the galvanized iron partitions located between the separate cake moulds, to loosen up the ice at the sides as the cross cut is made. There is no waste by this method, and cakes weighing 450 lbs. each are hoisted from the tank with ease. Instead of raising the temperature of the cake from 32° to 52°, as is necessary with the ordinary steam-operated ice-cutter, the hot water application raises the temperature at the sides but 1° above freezing, which conduces to coal economy as well as to the yield of larger cakes.

All the electric wiring is in iron conduits and a breakdown service is supplied from the circuits of the Worcester Electric Light Company. About 275 16 c.-p. lamps are installed in the power plant, warehouse and ice-making department.



Elevation of Freezing Coil

Sectional Elevation

Plan of Hot Gas Pipes

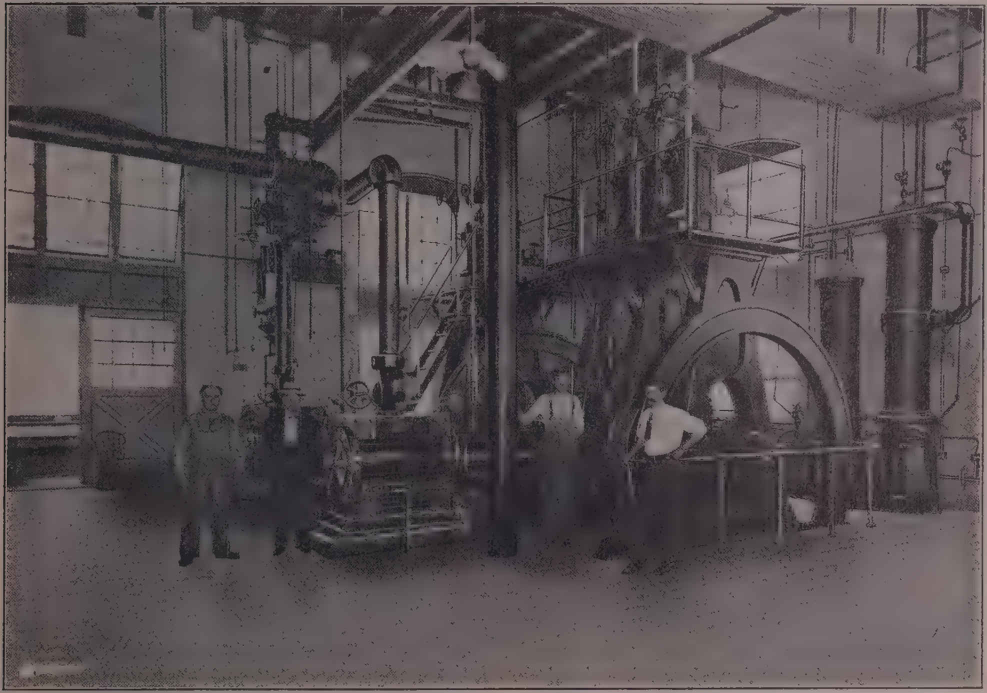
Part Plan of Freezing Coil

Arrangement of Coils and Partitions in the Freezing Tank.

Experiments with Tar and Oil on the Highways of Rhode Island.

A paper read before Section D of the American Association for the Advancement of Science. By Arthur Horace Blanchard, Associate Professor of Civil Engineering, Brown University; Assistant Engineer, State Board of Public Roads of Rhode Island.

In order that the results of maintenance experiments may be of maximum value to the highway engineer a description of the method employed on any specific highway or in a particular locality must be accompanied by a statement regarding local environments and the nature of the traffic to which the highway is subjected. The author, while reviewing descriptions of experiments in highway preservation in America, England, France and Germany, constantly felt the lack of adequate explanations of local conditions and an indefiniteness as to the cost of the various methods of construction. In the following paper the descriptions and cost data have hence been elaborated wherever possible in order that the results of the experiments in Rhode Isalnd would be of maximum value to those who might use them. As the experiments herein described were made on highways differing widely in local characteristics, it will be advisable to consider a tentative classification of the country highways. The conditions in Rhode Island are typical of many states and hence the proposed classification of highways is not local, although the continuous state highway system per se has not as yet been adopted elsewhere.



Refrigerating Machine in Worcester Cold Storage Plant.

It is practicable to recognize three classes of highways existing outside of the city limits, the classification being based on the amount and character of the traffic to which the roads are subjected. Naturally these classes merge into and overlap each other in many cases, but the classification will suffice as a basis for comparison. The first class includes interstate trunk lines and the popular routes of travel. The second class includes intrastate trunk lines passing through towns, the highways connecting towns situated within a few miles of each other and the secondary streets of towns. The third class includes feeders leading to towns and highways of the first and second class from sparsely populated parts of the country districts, those connecting towns which are many miles apart and the transverse feeders in towns.

The highways of the first class will undoubtedly be subjected to the heaviest motor car traffic, although not necessarily to the heaviest commercial traffic. The highways of the second class will probably carry heavy commercial traffic and a limited amount of motor car traffic. The third class of highways will usually be subjected in amount, at least, to the ordinary country highway traffic.

The maintenance of the highways of the third class which are constructed either of earth, gravel or broken stone, has been thoroughly and satisfactorily considered in the past. The highways included in the first and second classes, being subjected to a more or less heavy motor car traffic and an augmented commercial traffic, demand an entirely different method of maintenance and in many cases a modified construction of the broken stone surface. The amount of traffic and the speed attained by motor cars are the important facts to be considered in the discussions of methods employed for maintaining highways of the first and second class.

The experiments with tar and oil on the highways of Rhode Island have been undertaken for divers reasons. In many cases the primary object has been to reduce the amount of dust raised by a motor car to a minimum. In other cases the work was undertaken with the double purpose of reducing the amount of dust to a minimum and preserving the surface. Again the experiments have been made with the primary object of increasing the life of the road.

The construction of tar macadam in 1906 and 1907 on the Post Road in the Town of Charlestown was done under the supervision of the state engineers, the object being to obtain a road at a minimum cost which would withstand the destructive wear of swiftly moving motor cars. This State Road is a part of the interstate trunk line connecting New York City, Narragansett Pier, Newport, Providence and Boston, and hence belongs to class number one. With the exception of the addition of tar, the method of construction used was similar to that employed in the building of an ordinary macadam road. After the subgrade had been thoroughly rolled, the No. 1 broken stone, varying in size from 1¼ to 2½ in. in their longest dimensions was spread to a depth of 6 in. and rolled to 4 in. Tar, which had been heated in an ordinary tar kettle to the boiling point, was then sprinkled on the rolled surface by means of dippers. The No. 2 stone, varying in size from ½ to 1¼ in. in their longest dimensions, was next deposited on dumping boards and thoroughly mixed with hot tar with the aid of rakes and shovels. This mixture was applied on the number one course to a depth of 3 in. and rolled to 2 in. A thin coat of dust, which would pass through a half-inch mesh was then spread on the surface and then rolled into the No. 2 course to fill up the voids and to provide a smooth surface. It is, without doubt, unnecessary to state that the work was carried on only when the broken stone was dry.

The tar used in 1907 was produced at the Providence Gas Works and cost f.o.b. Providence, $2.75 per barrel. The freight from Providence to Niantic, the nearest railroad station, was $0.41 per barrel. The cost of the haul from Niantic to the State Road, a distance of 6½ miles, was $0.50 per barrel. The barrels cost $0.75 each, which amount, minus the freight to Providence, would be refunded by the gas company upon the return of the barrels. The location of the road rendered the return of the barrels an uneconomical procedure. The total cost of the tar per barrel was therefore $4.41. As two barrels of tar were used per 50 lin. ft. of road, 14 ft. in width, the cost per square yard of the tar used was $0.1132. The extra labor employed comprised three men at 20 cents an hour and two men at 17½ cents per hour. As the working day was ten hours, and 100 lin. ft. of macadam surface was built per day, the cost per square yard for the labor was $0.0609. The cost of accessories, which would include rent or interest and depreciation of tar kettles and dippers, and cost of fuel, was $0.0054 per square yard. The saving per square yard by not using a watering cart at $4.00 per day of ten hours, was $0.0171. The total cost per square yard, therefore, of the tar macadam in excess of the ordinary macadam was $0.1624. The amount of tar used per square yard was 1.15 gal.

In the fall of 1906, 350 lin. ft. were constructed, the location being on a curve section of the interstate trunk line in Charlestown. This sample withstood the severe test of a hard winter admirably, and likewise resisted the wear of the traffic during 1907 without perceptible alteration. As these results were gratifying, the State Board, during the fall of 1907, constructed the mile of tar macadam referred to above. Although this experiment was undertaken with the primary object of securing a more permanent surface, another desideration resulted, namely, the elimination of the objectionable dust. After a tar macadam road, constructed as described, has been in service a month a large percentage of the loose dust is either washed away by the rain or has been raised from the surface, primarily by the motor car, and blown away by the wind.

During the construction of the above road there would occur at irregular intervals small areas of a spongy nature. The lustre of the tar was lacking on the coated stones and the entire mass appeared to be impregnated with oil. Without doubt this condition was due to a lack of uniformity in the composition of the tar mixture in the several barrels used. It is well known that the percentage of ammoniacal liquors, light oils and water in a given barrel of tar depends to a great extent upon the amount of tar in the tank from which the contents of the barrel were drawn, and also upon the nature of the treatment at the gas works.

During the fall of 1907, Central St., Narragansett Pier, which belongs to the second class of highways, was built of tar macadam, the penetration method of construction being adopted. The tar compound used, known as tarvia, was furnished by the National Coal Tar Co., of Boston, the amount used per square varying from 0.81 to 1.61 gal., depending upon the size of the broken stone comprising the upper course. The macadam was constructed by spreading 6 in. of clean, dry No. 1 Connecticut trap rock on the rolled subgrade and rolling the same to 4 in. On the No. 1 course was then spread 2½ to 3 in. of clean, dry No. 2 Connecticut trap rock, which was lightly rolled. The tarvia, which had been heated in the regular tar kettles, was next poured on the surface of the No. 2 course and allowed to penetrate. The depth of penetration varied from 1 to 2 in., depending on the size of the stone comprising the upper course and the amount of rolling the surface had received. Trap rock chip screenings were then spread to a depth of ½ to ¾ in. and thoroughly rolled. There is no apparent reason why this form of construction should not give satisfactory results, but a year's service under traffic will be required before any opinion relative to its durability can be expressed.

As yet the Gladwell system of constructing tar macadam has not been tried in Rhode Island, but, without doubt, will be experimented with during the coming season. This system consists in spreading on the No. 1 course, after rolling a mixture of tar and chippings, to a depth of ¾ in. On this is deposited from 2 to 3 in. of No. 2 broken stone, which is thoroughly rolled, thus forcing the mixture into all the interstices of the No. 2 course. The upper surface is sealed by painting with tar after which a thin coat of fine screenings is spread and rolled.

The construction thus far employed of using tar as a preservative for roads already constructed is known as the painting method. In the fall of 1906 a section of 1,300 ft. in length of the State Road in the Town of Tiverton was painted with tarvia furnished and applied by the National Coal Tar Co. The usual method was employed of sweeping the dust from the surface of the macadam with stiff brooms, thus exposing the mosaic surface of the No. 2 course. The hot tar was poured on the No. 2 course and spread by brushing. A thin coat of sand was then spread over the tarvia coating. The price per square yard was $0.0804. This section was located on a hill having a maximum grade of 7.28 per cent, hence the durability and slipperiness during the service of the first year were carefully noted. The tarviated surface was able to shed the water to the gutters and to prevent the road from being gullied, while, contrary to the experience of English engineers with steep gradients, no unfavorable criticisms have been offered relative to slipperiness. The State Road in Tiverton belongs to the second class, but it is subjected to more than the average amount of motor car traffic, as it is a part of the interstate trunk line leading to the popular summer resort, Newport. After sustaining a season's motor-car traffic, the road surface has not scaled or been worn down to the No. 2 course.

In 1906 tar painting was experimented with on two curves on an interstate trunk line in the Town of South Kingstown. In both cases the edges have continually worn or scaled off.

During the month of August, 1907, one mile of macadam road of the second class, located in the village of Peacadale in the Town of South Kingstown, was tarviated. The method employed was similar to that used on the Tiverton road, except that the tarvia in this case was heated to 200° Fahr. in a special tarvia heater and spread directly from the tank car. The price per square yard was reported as $0.0487. As a whole the work has proved satisfactory, although the tarvia coating has scaled off in spots and on the edges.

The evident variation in the quality and composition of the various barrels of tar used on the same highway and the recognition of the possibility of securing a more efficient binder were instrumental in having samples of tar examined and analyzed. Thus far five samples of materials of a tarry composition which could be used in tar macadam or as a surface palliative have been analyzed. These include one sample of tarvia furnished by the National Coal Tar Co., of Boston, two samples of coal tar furnished by the Providence Gas Co. and two samples of terracolio furnished by the Good Roads Co. of America.

PERCENTAGE COMPOSITION OF ROAD TARS.

Samples.	Tarvia.	Tar.	Tar.	Terracolio.	Terracolio.
Volatile at 120° Fah.	12.35	10.66	6.77	0.53	14.46
Additional loss at 212°-220° Fah.	17.28	15.33	16.12	0.18	5.88
Additional loss at 240°-260° Fah.	6.48	4.67	4.99	0.18	0.67
Total volatile matters at 260° Fah.	36.11	30.66	27.88	0.89	21.01

ANALYSES OF SAMPLES DIGESTED WITH EQUAL VOLUMES OF WATER.

	Tarvia.	Tar.	Tar.	Terracolio.	Terracolio.
Color,	Water white.	Brown.	Brown.	Water white.	Water white.
Odor,	Carbolic Acid.	Carbolic Acid.	Carbolic Acid.	Slightly tarry.	Slightly tarry.
Reaction,	Slightly Acid.	Alkaline (Free ammonia).	Alkaline (Free ammonia).	Neutral.	Neutral.
Total solid matters, grains per gallon	8.75	46.69	102.15	5.84	11.68
Organic and volatile	8.75	37.94	99.23	2.92	5.84
Mineral matters	None.	8.75	2.92	2.92	5.84

It should be noted that the percentage of volatile constituents which evaporated at 120° Fahr. fairly represents the percentage which would be lost from the tarred surface of a highway during a summer season. The object of digesting the tar in water was to determine the amount of matter which might be washed from the surface of a road by a heavy rain. This combination was not shaken vigorously, but simply turned once in order to obtain experimental results which would conform to actual conditions on the highways.

The results obtained from the analysis of the samples of tar from the Providence Gas Co. indicate that the variation in composition may have an important influence on the character of a tar macadam road. The fact that only one sample of the other tar products was analyzed should be considered in drawing conclusions from the results tabulated.

Judging from the results tabulated, it is obvious that if it is desirable it will be possible by washing the crude tar with water and heating a certain number of hours at a temperature of 120° to 150° Fahr. to remove those constituents which would volatilize or be washed away during the first season of service. The spongy nature of certain portions of the tar macadam at Charlestown and the self-evident possibility of a porous tar macadam road under certain climatic conditions indicate the desirability of experiments with tar which meets certain definite specifications. Without doubt this phase of the use of tar will be thoroughly investigated during the season of 1908.

ANALYSIS OF OILS OFFERED AS DUST PREVENTIVES.

Sample.	Residuum.	Fuel Oil.	Crude Oil.	Dustoline.
Specific gravity	0.907	0.854	0.909	0.854
Flash point	240 Fahr.	105 Fahr.	180 Fahr.	260 Fahr.
Burning point	300 Fahr.	170 Fahr.	220 Fahr.	390 Fahr.
Volatile at 120° Fahr.	14.91%	2.25%	14.13%	1.14%
Additional loss at 212°-220° Fahr.	6.98%	49.01%	8.64%	6.62%
Additional loss at 240°-260° Fahr.	9.71%	30.42%	6.86%	13.01%
Total volatile matters at 260° Fahr.	31.60%	81.68%	29.63%	20.77%

ANALYSES OF SAMPLES DIGESTED WITH AN EQUAL VOLUME OF WATER.

Sample.	Residuum.	Fuel Oil.	Crude Oil.	Dustoline.
Color,	Water white.	Water white.	Water white.	Water white.
Odor,	None.	Petroleum.	None.	Paraffin Oil.
Reaction,	Neutral.	Acid (Free Sulphuric Acid).	Neutral.	Neutral.
Total solids, grains per gallon,	Trace.	52.53	5.83	5.84
Organic and volatile,	Trace.	52.53	5.83	2.92
Mineral matters,	Trace.	None.	None.	2.92

The treatment of macadam roads with oil during 1906 and 1907 by the State Board of Public Roads was undertaken with the idea of not only suppressing the dust but also of preserving the road surface. Without doubt some of the towns in Rhode Island which have experimented with oil only considered the results from the standpoint of the solution of the dust problem. During the month of July, 1907, 32,242 sq. yd. of the State Road in the Town of Barrington were treated with an oil known as "petroleum residuum," which was supplied by the Standard Oil Co. from their tanks at Bayonne, N. J. The oil was applied cold by means of an ordinary sprinkling cart to the surface of the road from which the dust had not been removed. The amount of oil applied per square yard was 0.214 gal. The cost of the oil in the tank cars at Barrington Center, which is on the State Road in question, was $0.046 per gallon. The cost of the labor per square yard was $0.0031, making the total cost per square yard $0.0105. Some damage was done during the three or four days following the application, particularly to motor-cars, carriages and wearing apparel, but the coagulated dust did not pick up after the traffic had matted the surface, except during and immediately following a hard rain. The treatment was successful from the standpoint of suppressing the dust, and as the retention of the dust preserves the surface of a macadam road it has, without doubt, increased the life of the road. The application of the oil, however, did not furnish a binder of sufficient tenacity to prevent the No. 2 course from raveling when it was subjected to a combination of unfavorable climatic conditions and heavy motor-car traffic. The efficacy of this treatment was apparent after five months of service, but it is not expected that the surface will be in such condition in the spring as not to require a second application in order to make the road dustless. This highway belongs to the second class, receiving the normal amount of motor-car traffic for roads of this type.

The Highway Commissioner for the Town of Cranston has used oil on the town roads since 1901. The highways with but two exceptions belong to the second and third classes, the two exceptions being parts of interstate trunk lines on the State Highway System. The effect of one application has lasted from ten to thirteen weeks, hence the usual practice has been to make two applications per year. The oil used, petroleum residuum, is obtained from the Standard Oil Co.'s plant at Bayonne, and costs delivered in tanks on side tracks in Cranston $0.46 per gallon.

The State Road in the Town of Middletown belongs to the first class, for although it is an intrastate trunk line, it is at the same time part of one of the popular drives out of Newport. This highway was treated during July, 1907, with dustoline, the number of square yards covered being 20,765. The dustoline was spread by means of a watering cart on the surface of the road from which the dust had not been removed. The total number of gallons used on the work was 7,261, but as some sections received two applications the amount used per square yard is indeterminate. The dustoline cost, f.o.b., Summit, N. J., $0.0775 per gallon, the total cost being $562.73. As the freight from New Jersey to Providence was $69.70 and the cost of labor required to spread the material was $97.66, the average cost of the application per square yard was $0.035. The efficacy of the treatment from the standpoint of laying the dust has not been questioned. After three months the effect of the application had practically disappeared. An objection to its use has been offered due to the fact that motor cars throw small coagulated particles of dust into the air, which are decidedly injurious to wearing apparel.

Dustoline has been used on many of the principal boulevards of Newport, giving perfect satisfaction, according to the statements of the officials of the Department of Streets and Highways. The object of the treatment was to suppress the dust more satisfactorily and economically than had previously been done by watering.

The many varieties of oil offered to the State Board of Public Roads suggested the advisability of analyzing some of the oils used as palliatives. The samples included three varieties furnished by the Standard Oil Co., and a sample of dustoline furnished by John S. Lamson, Jr. The results are shown in an accompanying table.

Judging from the results of the experiments made in Rhode Island and elsewhere, it is obvious that investigations should be made during the coming season covering the following important subjects: 1, Relation of the composition of tar to the efficiency of a tar macadam road and tar painting. 2, Comparison of the efficiency of tar macadam constructed under varying climatic conditions by the mixing method employed at Charlestown, by the penetration method and by the Gladwell system. 3, Economic value of loosening three or four inches of an old macadam road with a scarifier, reshaping the surface and reconstructing the surface with the addition of tar by the penetration method. 4, Methods of increasing the bond between the tar matrix and the surface of an old macadam road. 5, Efficiency of various machines used for spreading tar and special machinery used in the construction of tar macadam roads. 6, Efficiency of roads treated with the various oils on the market, with cold and hot oils, with and without the sand dressing, with and without rolling.

The author firmly believes that in the future more stress should be laid on the economic construction of more permanent macadam roads for highways of the first and second classes and that less attention should be paid to the various surface palliatives.

The Mileage of Streets in Boston has increased at an unusually rapid rate during the past 20 years for a city as large and as old as Boston. According to the report of Mr. James H. Doyle, Superintendent of Streets, for 1906, the total mileage of public streets in 1890 was 404.6 miles; in 1900 this had increased to 489.55, and at the beginning of 1907 the total was 510.04 miles. The character of pavement on these streets, Feb. 1, 1907, was as follows: Asphalt, 21.45 miles; granite block, 96.53; wooden block, 1.43; plank on bridges, 2.04; brick, 0.38; cobble, 0.45; bitulithic, 5.83; macadam, 341.22; gravel, 35.28; not graded, 5.43.

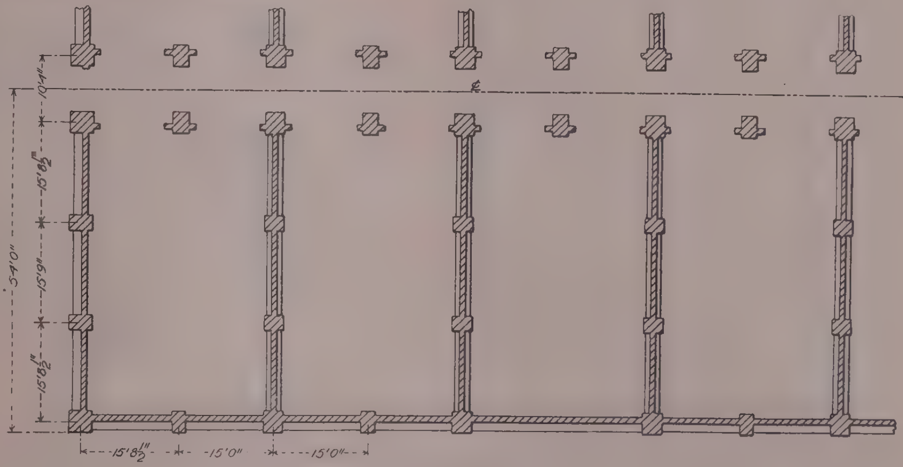
A Reinforced Concrete Cement Stock House.

By A. Jordahl, Assoc. M. Am. Soc. C. E.

The plant, which is now being built at Longue Pointe, near Montreal, Canada, for the Vulcan Portland Cement Co., is of fireproof construction throughout. The buildings comprise a stone house, coal mill, cement mill, kiln building and clinker storage building, all of which are of steel-frame construction; the remainder, namely, a stock house, two packing houses, six limestone bins, a machine shop, transformer house and office building, are of reinforced concrete.

Of the latter group, the stock house is the largest and most interesting from a structural standpoint, and will therefore be described somewhat in detail. The dimensions over all are 180 ft. for the width and 245 ft. 3 in. for the length, exclusive of the packing houses, while the height from the ground to the eaves is about 35 ft. At each end of the building there is a packing house 108 ft. wide and 30 ft. long. The stock house is divided by a gallery 10 ft. wide into two equal portions, each of which is subdivided into eight bins, about 30 ft. long and 49 ft. wide center to center of columns. The partition, as well as the outside walls and columns, are of reinforced concrete, and the floor of plain concrete resting on an earth filling. The roof has a pitch of 6 in. to the foot, and is constructed of steel trusses on 15 ft. centers, steel purlins, wooden sheathing and composition roofing. It has a monitor extending the full length of the building. All interior walls are carried up to the same height as the side walls, while the gable walls extend 12 in. above the roof and form parapets. The stock house has a capacity of about 240,000 bbl., and will be used for the storage and seasoning of cement in bulk.

Cement Stock House of the Vulcan Portland Cement Co., Montreal.



Quarter Plan of Cement Stock House at Montreal.

The cement is conveyed from the cement mill by a belt conveyor running perpendicular to the longitudinal axis of the stock house, and entering the side of the monitor in the first bay from the end. It is here discharged into two 12-in. screw conveyors, running the entire length of the monitor, which discharge it through spouts into any desired bin or into the gallery. The cement is drawn from the stock house by means of two screw conveyors rotating in troughs formed in the concrete floor of the gallery. By these it is conveyed to the packing houses at each end of the building and is there elevated by bucket conveyors and discharged onto a screen, through which it passes to the weighing hoppers and packing machines. Standard gauge tracks run along each side of the stock house and packing houses, and the floors in the latter serve as shipping platforms.

The system of reinforcement adopted for this building represents a radical departure from the usual practice of reinforced concrete construction. The column and beam reinforcement and the ties connecting the columns on opposite sides of the bins, are all of structural steel shapes with riveted connections. These members were manufactured in a structural shop, shipped to the job, and when erected formed a self-sustaining steel skeleton frame of great rigidity and of ample strength to support the wooden forms and scaffolding, as well as the plant for handling and distributing the concrete.

The walls are of ribbed construction designed for carrying the side load thrust of the loose cement by a system of beams and girders, much after the fashion of the conventional reinforced concrete floor system. The beams run horizontally and transfer their loads to the columns which, at the same time, act as girders. The wall slabs throughout the building are 10 in. thick, except in the gable walls, where they are 11 in. thick. The spacing of the ribs increases from the bottom up so that the bending moments on the slabs are approximately the same for all panels. The wall slabs are reinforced with ¾ in. rods placed vertically near the outside face of walls, and with ½-in. vertical rods placed opposite all beams near the inner face. The beam reinforcement in all but the partition walls consists of a T-section made of two steel angles, of which the long legs are placed vertically, and the short legs are riveted together back to back and turned towards the bin. They vary in section from 6 x 4 x ⅝-in. to 3 x 2½ x ⅜-in., and are protected with 1 in. to 1½ in. of concrete or mortar on all sides, making the width of beam 14 in. in most cases. The depth of beam outside the slab is constant, and is equal to 18 in. for all except the gable walls.

At the columns, the beams are reinforced with four ¾-in. rods, 6 ft. long, placed near the inner face of wall. From 24 to 60 ⅜-in. stirrups were used in the beams; one-half of the number of U-shape, with the ends of the legs bent to hook into 7/16 in. holes punched in the vertical legs of the angles and the other half consisting of single rods, hooked into holes in the horizontal legs of the angles. These stirrups were provided to augment the shearing resistance of the beams, to furnish the necessary mechanical bond between the angles and the concrete, and finally to prevent the concrete scaling off the outside of the angles.

The intermediate columns, which also act as girders, are reinforced with four 6 x 4 x 7/16-in. angles arranged in double T-section, with the long legs perpendicular to the plane of the web and the short legs of the outside pair turning away from the center line of the column. This was done to give the beam reinforcing angles direct bearing on the outside column flange, and to admit of simple connections. All other columns have four 6 x 4 x ⅜-in. angles arranged in substantially the same manner. Column binders of ⅜-in. diameter rods, spaced 18 in. on centers, were used throughout.

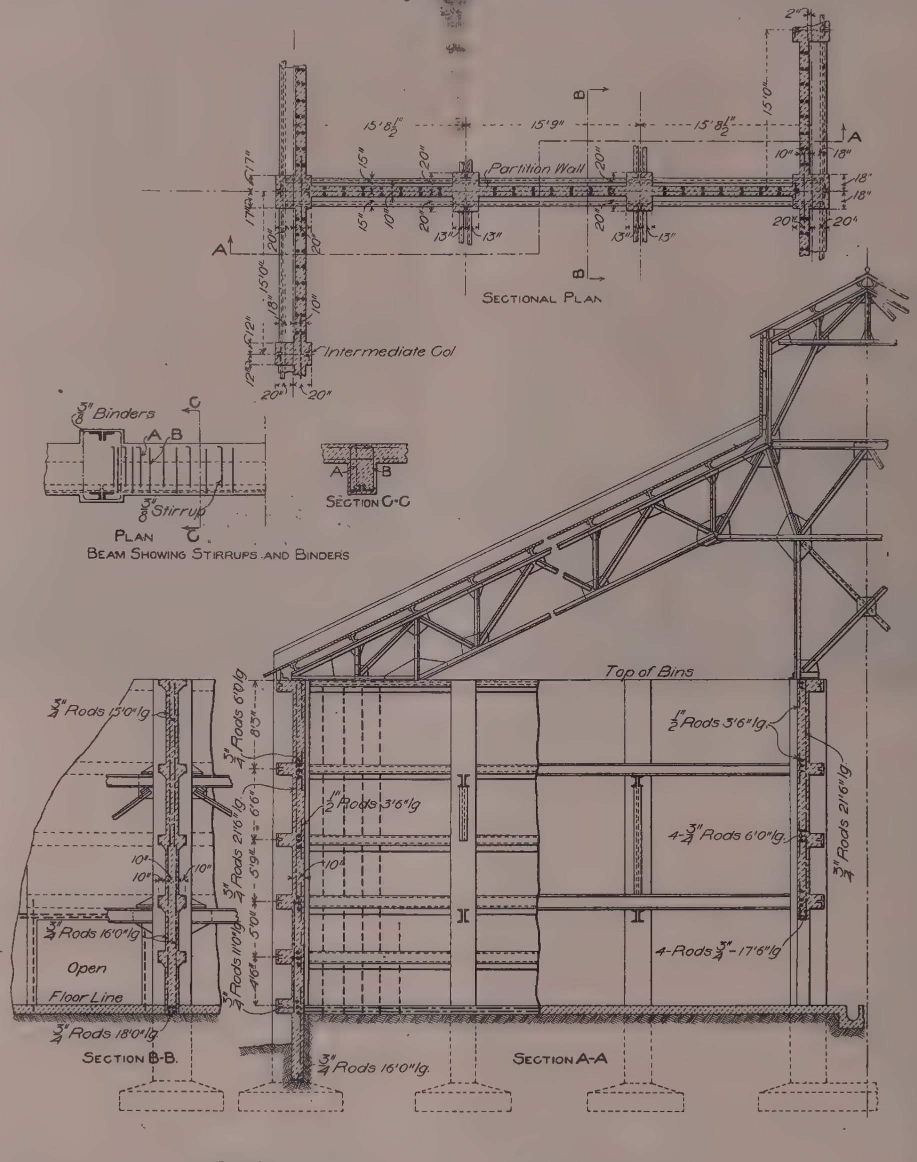
The columns have riveted base plates, provided with holes for four 1⅛-in. anchor bolts, which were concreted into the footings. To permit of a slight inaccuracy in the setting out of the foundation bolts, they were encased in 2-in. iron tubes, which were later filled with liquid cement grout.

The partition walls and columns are symmetrical with respect to a vertical plane through their center. The beams consist of two steel channels, one on each side of the slab with the backs outward, facing the bins; they are riveted to the columns and are tied together by means of through bolts, and filled with concrete. The channels are spaced at the same elevation as the corresponding outside and gallery wall-beams, to which they connect by means of bent-plate straps.

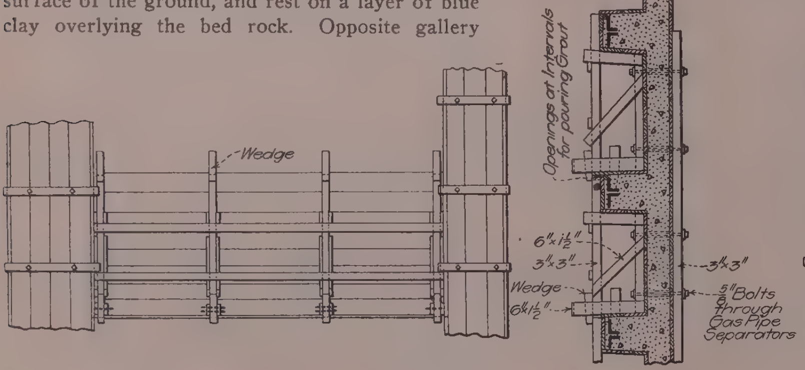
The opposite walls of each bin are tied together by means of steel channel ties riveted to large gusset plates on the intermediate columns. There are two sets of these connecting the partition walls, each set consisting of two ties which are trussed in a vertical plane to prevent sagging. The columns in the outside and gallery walls are connected by one set consisting of three ties, of which the bottom one is flush with the bin floor, and the two upper ones rest on the corresponding partition ties. In addition to these, the gable walls are stiffened with horizontal and vertical diagonal ties, anchored back into the outside and gallery wall columns.

A condition of the design was that the gallery be the last to be filled and the first to be emptied, and for this reason no ties were provided between opposite gallery columns, but light channel braces were introduced for erection purposes.

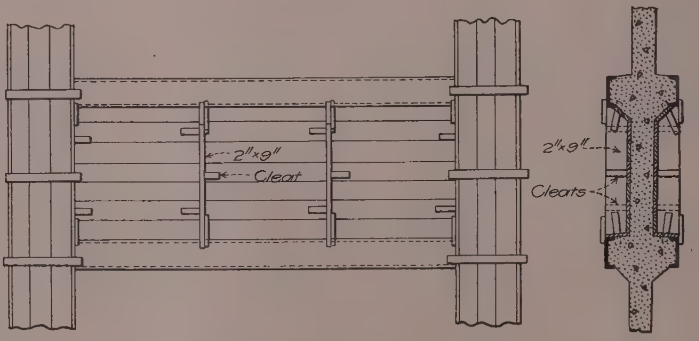
The columns are supported on spread reinforced concrete footings, proportioned according to the loads. These are carried 6 ft. below the surface of the ground, and rest on a layer of blue clay overlying the bed rock. Opposite gallery columns have combined footings; all others are single.



Sections and Part Plan of Cement Stock House.


Wedge
Openings at Intervals for pouring Grout
6"x1½"
3"x3"
Wedge
6"x1½"
3"x3"
⅝" Bolts through Gas Pipe Separators

Forms for Outside Walls.



Forms for Partition Walls.

The concrete in the footings was proportioned of 1 part cement, 3 parts sand and 5 parts stone broken to 2-in. size or smaller. The remainder of the concrete, except in the floors, consisted of a 1:2:4 mixture, the broken stone having a maximum size of ¾ in. The aggregate was a fair quality of limestone, which was quarried and crushed on the job. It contained a large proportion of dust, which formed into clay on coming into contact with water; for this reason all stone, except for footings and floors, was screened.

Outside of the structural steel, plain round rods were used for reinforcement throughout. All connections were riveted, pneumatic hammers being used for most of the work. All steel, which was to be embedded in concrete, was left unpainted. The ties and the outside faces of partition channels were given two coats of paint in the shop.

The structural steel was manufactured by the Structural Steel Co., of Montreal, Canada, and was delivered at the site complete within six weeks after placing the order.

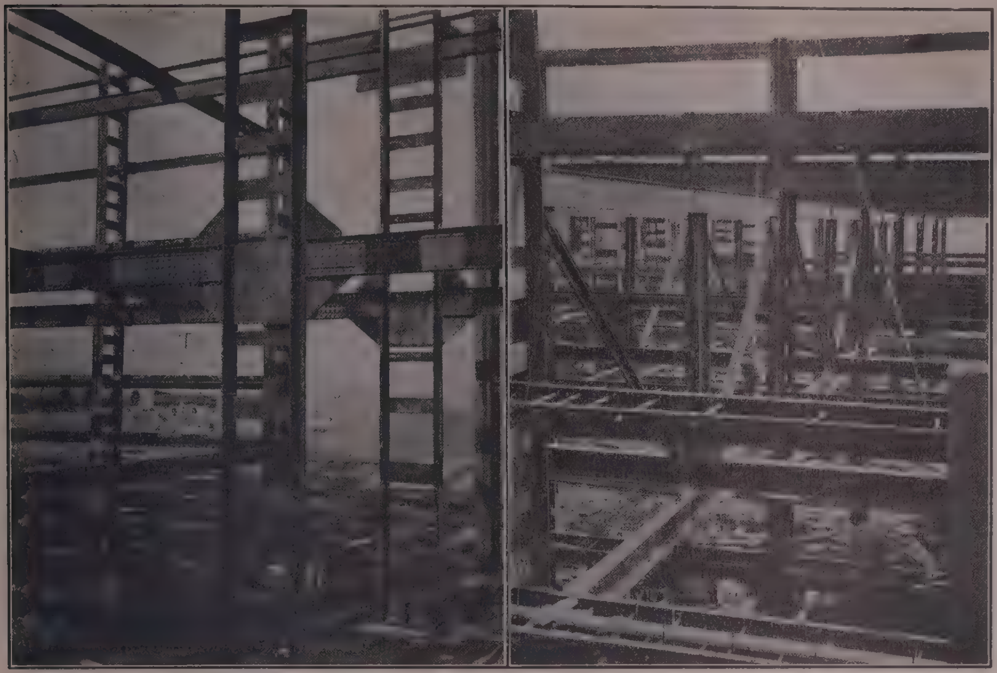
Design.—The adoption of the form of construction described above was prompted by the peculiar character of the building, as well as by local and labor conditions.

The cement pressure on the four sides of a bin produces bending moments, shear and direct tension in every beam and wall. Had rod reinforcement been used, the connections, in order to transmit these stresses, would have necessitated a large amount of blacksmith work and bending. Apart from the great expense which this would incur, it was considered doubtful whether connections of sufficient strength could have been effected, as the strength of bent rods, or hooks, is at the best an extremely uncertain item, especially when the work has to be performed in the field with unskilled labor.

On account of the poor quality of labor which is available for reinforced concrete work in Canada, and because the preparations for this building were started so late in the season that its construction would have to be carried on under very unfavorable weather conditions, it was deemed necessary to design the building in such a way that there could be little or no possibility of poor and inaccurate workmanship.

It was also realized that the high walls, without any intermediate floors, would render the erection and alignment of forms extremely difficult and expensive without some stiff skeleton frame on which to support them.

That the design decided upon met these various conditions admirably was fully substantiated during the construction of the building.



Structural Steel Reinforcement of Cement Stock House.

Very few data are available relating to the lateral pressure of cement. It has been observed that it assumes a curved surface, whose maximum slope occurs under the point of discharge and grows comparatively flat further out. This indicates that the lateral pressure would vary, according to the distance from the discharge spout.

For the purpose of determining the pressure on the walls, a constant angle of repose of 15 deg. was assumed, and the weight of the cement was taken at 100 lb. per cubic foot. The pressures were obtained by inserting these values in Rankin's formula for surcharged walls.

Experiments have shown that the pressure is greatest immediately after the cement has come to rest, indicating that in large bins, requiring several days to be filled, the pressure would be less than given by the above formula. For this reason it was deemed permissible to increase the working stresses on the steel and on the concrete, somewhat beyond the values usually adopted.

The beams in the outside, gallery and gable walls were figured as T-beams. The partition wall beams were not designed on the principle of reinforced concrete, but were treated as lattice girders with the steel channels acting as chords, and the through bolts and the concrete filling as web members.

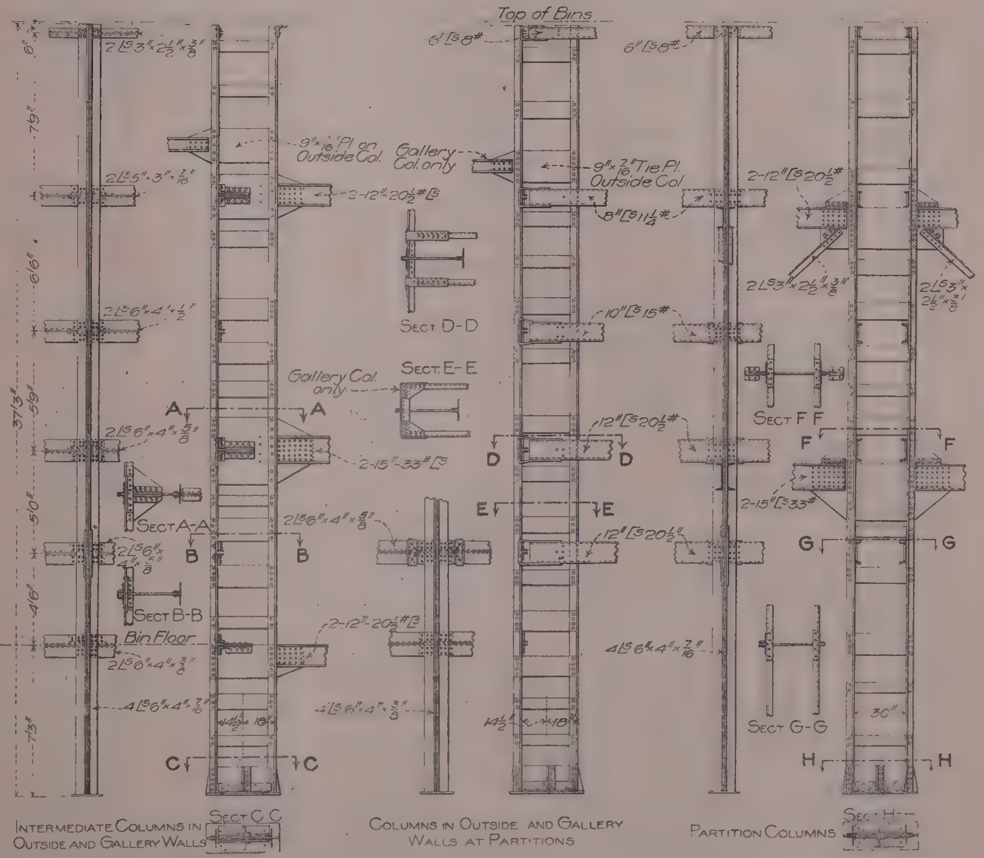
In addition to the lateral pressure, the walls, columns and footings were figured for vertical loads composed of the live load on the roof, the weight of the structure and friction loads. The latter were based on an assumed coefficient of friction of 0.55 for the plain walls and a somewhat higher value for those having ribs in contact with the cement.

The partial continuity of slabs, beams and columns was taken into consideration in the calculations.

Construction.—The reinforcing rods were ordered to length from the mill, and the little cutting required was done with a 1⅛-in. rod shear. The stirrups and column binders were bent cold by a simple lever contrivance attached to a bench and operated by one man.

The forms for the concrete were made in a temporary carpenter shed erected for this purpose close to the stock house, and equipped with motor-driven saws and other necessary tools.

Forms were at first provided for one complete quarter section of the building, and it was the intention to re-use these till the job was completed. On account of weather conditions, it was afterwards decided to provide some additional forms and start operations at the other end of the structure. As a result of this the first set of forms was actually used only three times.



Structural Steel Reinforcement of Columns.

The wall forms, typical cross sections of which are shown, were made up on the ground into sections, each covering one entire wall panel, between adjacent beams and columns, including the corresponding column sides; the front and back of the columns were covered by separate sections. The principal lumber used was 1½-in. tongue and groove hemlock, dressed one side. The sides of columns and beams were battered ⅜ in. to the foot to permit easy removal of the forms. All surfaces of the forms in contact with concrete were oiled.

Two guyed derricks operating abreast on top of the steel frame, one on each side of the gallery, handled the forms as well as the concreting on three-fourths of the building. The remainder was built with a hoisting tower and one stiff-legged derrick, put up as a last resort in order to complete the work before severe frost set in.

The form sections for the outside face of wall were generally erected complete to the top and supported on the steel frame before any concreting was done. The reinforcing rods were then placed and held in position by means of wooden strips nailed to the outside forms, and provided with notches or holes for the rods. The inside forms were then erected section by section as the concreting progressed, and were held in position by pipe separators and bolts passing through the outside forms. The wooden spacers for the reinforcing rods were removed before the concreting reached them. The concrete was mixed with two Ransome mixers mounted on trucks and located on each side of the building between two successive positions of the derricks.

Two 14-cu.-ft. contractors' tipping buckets operated by the guyed derricks transferred the concrete from the mixer hoppers to the walls. When a section within the reach of the booms was completed, including the moving of forms, the derricks were moved forward.

The instructions issued to the field force provided that the maximum dump of the concrete should not exceed one panel height, and, further, that construction joints would be permitted only at the center line of beams and columns. Concreting was permitted whenever the temperature was above +15 deg. Fahr. When below +40 deg. Fahr. the stone, sand and water were heated and steam discharged into the mixer. All fresh concrete less than 12 hr. old was protected from freezing.

The packing houses at each end of the stock house are of light steel-frame construction on concrete foundation walls. They have roofs similar to the stock house, but the walls are formed of Trussit metal clipped to the steel girts and plastered on both sides with cement.

The principal quantities involved, exclusive of the packing houses, are: Concrete (not including floors), 3,570 cu. yds.; fabricated steel (not including roof), 510 tons; steel rods, 103 tons.

Work on the footings was started Sept. 2, and the concreting of the walls was completed Nov. 28, 1907. All steel was inspected at the mills, and each carload of cement was sampled and tested at the job in accordance with the specifications of the Canadian Society of Civil Engineers.

All the work was carried out by W. S. Barstow & Co., of New York, engineers, the writer having charge of the concrete work for that concern.

Stresses in Masonry Dams.

On Jan. 21, the Institution of Civil Engineers held a meeting at which three papers relating to the determination of stresses in masonry dams were presented. This subject has been receiving particular attention in Great Britain during the last four years, and the papers were, in a sense, a summary of experimental and theoretical work done during this period which has aroused much discussion. The first paper, on "Experimental Investigations of the Stresses in Masonry Dams Subject to Water Pressure," by Sir John W. Ottley and Dr. A. W. Brightmore. The experiments were carried out in the shops of the late Royal Indian Engineering College at Coopers Hill, and occupied from first to last a period of about 14 months. They were restricted to models of a dam of typical triangular section under perfect conditions. The models were made of "plasticine," a kind of modelling clay, which appeared likely to reproduce on a small scale many of the conditions existing in a full size structure. The specific gravity of this material is 1.33; its temporary elastic limit in tension is about 2 lb. per square inch, whilst its temporary elastic limit in compression is about 2 lb. per square inch. The word "temporary" is used in this connection because, after a time, the plasticity of the material obscures its elastic tendency. It was also found that "plasticine" possesses a property of peculiar value in such experiments, in that, notwithstanding its plasticity, it will crack quite short along the plane of maximum tension when subjected to relatively small tensions for a sufficiently long period.

The dam was first modelled of triangular section with the vertical face exposed to the pressure of the water, the base being made equal to the height divided by the square root of the specific gravity of the plasticine, so that the resultant of the pressure on the base (due to the weight of the model dam itself and the pressure of the water) would act at one-third of the width of the base from the outer toe. The height of the model was taken at 30 in., which therefore gave a base of 26 in. The length of the dam was 12 in. In subsequent experiments the width of the base was reduced to 23, 20 and 17 in., whilst in one case a sloping face was adopted.

The model was moulded in a frame furnished with thick plate-glass sides, and, in order to permit accurate measurement of any displacement in the model, corresponding horizontal and vertical lines, 2 in. apart, were scratched on both the glass and the plasticine. The glass sides were made adjustable, and, previous to the application of water-pressure, care was taken to see that the lines on the glass coincided accurately with the corresponding lines on the plasticine. A clearance was left between the glass sides and the model, to ensure that the latter should receive no support from friction between it and the glass.

Water-pressure was applied to the face of the model by water contained in a thin rectangular india-rubber bag made to fit the frame.

The weight of the model as first made (with a 26-in. base) was 230 lb., the water-pressure on the vertical face being 195 lb. This gave an average value for the intensity of normal pressure on the base of about 0.74 lb. per square inch, and an average intensity of shearing stress over the horizontal base of about 0.62 lb. per square inch, thus keeping well within the elastic limit of the plasticine.

One of the diagrams submitted with the paper represents the displacement of the originally vertical and horizontal lines after the water-pressure had been left on for one day. After these measurements had been taken, the water was siphoned off, and it is worthy of notice that in the course of a few days the model entirely recovered its original form, thus showing that the material was elastic under the pressure to which it had been subjected for the comparatively short period of one day.

More important results were obtained when the water-pressure was left on for a longer time so as to allow the model to become permanently deformed owing to its plasticity, as it thus became possible to show more definitely the distribution of the stresses in the structure. A diagram shows the state of the model after the water-pressure had been left on for 33 days, a crack at the inner toe having commenced to appear after seven days.

After detailing the method of calculation adopted, it is pointed out that both the recorded displacements of the lines on the model and the calculations based on these indications show that, although the old assumption that the shearing stress is proportional to the normal stress does not hold good at the base (because the dam is "fixed" at that level), yet at higher levels it is approximately correct, and that, therefore, the shearing stresses to be provided against are not those at the base, but at rather higher levels near the outer profile.

It is further pointed out that although a dam may be designed so as to have no tension on the horizontal plane at the inner toe when subjected to water-pressure, still there are other tensions on other planes passing through that point and it is suggested that the plane of maximum tension at the inner toe can be made more vertical by tying the front part of the dam into the foundation below the level of the base.

The permissible values of compressive and shearing stresses in dams are then considered, and the following final conclusions are drawn:

(1) If a masonry dam be designed on the assumption that the stresses on the base are "uniformly varying," and that these stresses are parallel to the resulting force acting on the base, the actual normal and shearing stresses, on both horizontal and vertical planes, would (in the absence of stresses due to such factors as changes in temperature, unequal settlement, etc.) be less than those provided for.

(2) There can be no tension on any plane at points near the outer toe.

(3) There will be tension on planes other than the horizontal plane near the inner toe; the maximum intensity of such tension being generally equal to the average intensity of shearing stress on the base, and the inclination of its plane of action being about 45 deg.

The second paper was entitled "Stresses in Dams: An Experimental Investigation by Means of India-Rubber Models." The authors, Messrs. J. S. Wilson and W. Gore, undertook the experiments as a result of an account of experiments with jelly models given by Sir Benjamin Baker in a discussion before the Institution. The two india-rubber models experimented with are 1 in. thick and to a scale of 1/240 represent sections of dams cut off by planes 20 ft. apart. The profiles of both models are the same in the upper parts, but at the base one section joins the foundations by curves, and the other section by sharp angles. In each case the dam-like portion is about 6.3 in. high and the foundation portion is 4 in. high and 12 in. long. Each model is divided into imaginary prisms and from the center of gravity of each prism a weight is suspended, the virtual specific gravity of the whole model being thereby increased to about 40. The water-pressure acting on the up-stream face is reproduced by plates pulled against the model by cords attached to weights, calculated so as to represent a fluid having a density of 40/2.25. The apparatus is arranged so that the weights, representing the masonry and water-pressure, can be supported by the model or by an independent frame. The models are made of such shapes that when fully strained they assume the profiles as designed.

Attention is called to the fact that to take up the greater part of the strain corresponding with a given stress, rubber requires a period of about 24 hours. To regain its original form a similar period is necessary. The relationship between direct stress and the strains produced in three directions, for the quality of rubber used, was tested by an apparatus described in the paper. The results of tests are plotted as curves, which prove that the strains are directly proportional to the stresses within the limits of the tests.

The strains are measured by the aid of photography. A pair of photographs are taken of the model; one when it is strained, and the other when it is unstrained. Black lines ruled on the light surface of the rubber appear on the photographic negatives as clear lines on a dark ground. The distances and angles between these clear lines are accurately measured with specially constructed scales and micrometer gauges.

The dam-like portion of each section was designed to represent a dam 125 ft. high, and the profile was calculated, according to the best principles so far suggested, to fulfil certain requirements with reference to the absence of tensile stress and the maximum compressive stresses. The various principles are set forth in the paper.

The vertical, horizontal and shear strains are combined as required by the equations relating stress and strain in two dimensions. The equations used are given in an appendix, and the experimental verification of some of them is given in the paper.

Three sets of experiments were carried out with the models, and the stresses determined in each case are indicated in diagrams of ellipses of stress and three sets of curves, two giving the distributions of normal pressure on horizontal and vertical planes, and the third giving the distribution of shearing stress on one of those planes.

The following are some of the conclusions given in the paper:

(1) Tensile stresses may exist at the up-stream toe of a dam, notwithstanding the fact that the line of resistance lies well within the middle third. The tension may be reduced by (*a*) making the up-stream face vertical, or by otherwise increasing the weight of the dam toward that face; this would have the effect of increasing the stresses in the dam when the reservoir is empty; (*b*) by a general increase in the dimensions of the dam; (*c*) by placing an earth embankment against the down-stream face.

(2) The direct stresses at the down-stream toe are compressive in every direction, but reduce to zero in the direction normal to the face.

(3) The maximum compressive stresses in a dam above its foundations are in a direction

approximately parallel with the down-stream face and generally some distance therefrom. In magnitude they are slightly greater than $P_t/\cos^2\phi$, where P_t is the maximum normal pressure on a horizontal plane as determined by the trapezium law, and ϕ is the angle between the resultant and the vertical.

(4) The shearing stresses are considerable at or near the up-stream toe. They are a maximum a short distance from the down-stream face, in a plane approximately at 45 deg. to the face. The maximum shearing stresses are in magnitude equal to $P_t/2\cos^2\phi$.

General View of Sewage Testing Station, Baltimore.

(5) The stresses in the foundations are of less consequence than in the dam above the base, because of the lateral support and the more extended distribution.

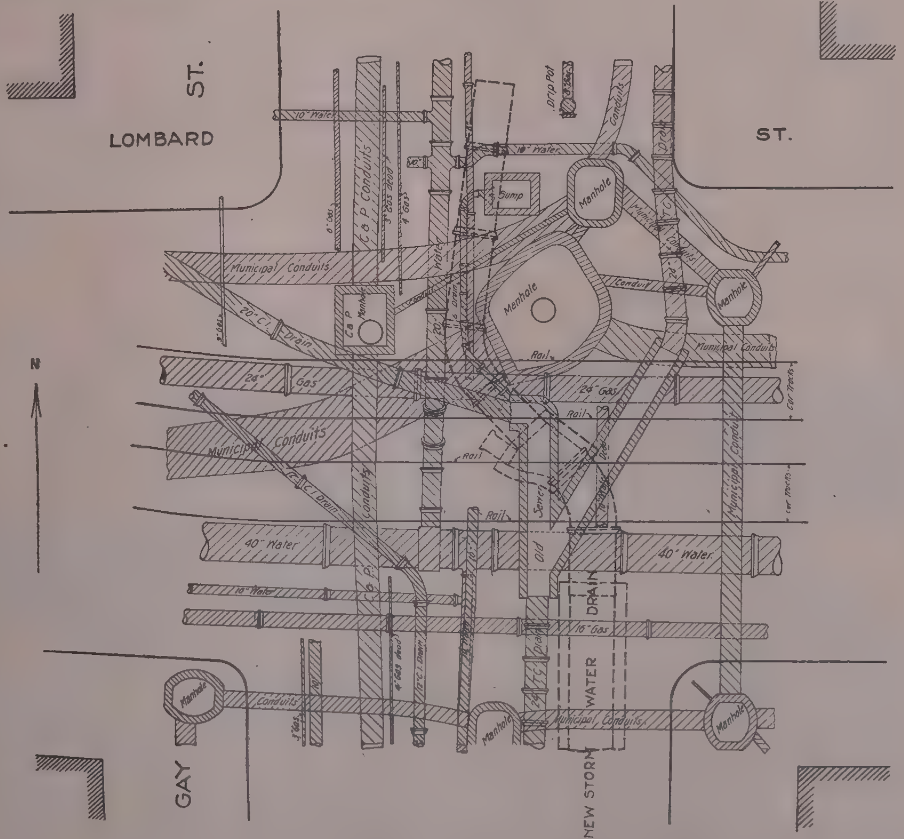
(6) The stresses are considerable at the toes of a dam if they form sharp angles with the foundations. These stresses may be reduced by replacing the angles with curves of large radii. The curve at the up-stream toe may take the form of a rounded quoin, cut in large stones, so as to avoid joints, in the masonry, normal to the direction of the greatest tensile stress.

The third paper, on "Stresses in Masonry Dams," was by Mr. E. P. Hill and explained a method of analysis based on the assumption that the vertical pressure on the base varies uniformly from one side to the other. From this assumption principal stresses are derived which vary considerably in magnitude and direction from those computed by customary methods. The stresses in the Periyar dam have been investigated in this manner, and are shown in a diagram accompanying the paper.

A NOVEL GAS ENGINE STARTER has been developed by the Oil City Gas Engine Co., consisting of a flash boiler furnishing superheated steam at high pressure which may be used in the gas engine in the same manner that compressed air is for starting large engine units. The boiler is of the coil type and of small capacity, and is heated by a large gas burner. In operation, the coil is heated to redness and then a small quantity of water is injected by a hand pump, which instantly flashes to steam of 400 to 500 lb. pressure and is ready to be admitted to the engine cylinder. The first heating of the coil will furnish sufficient steam to turn an engine over a number of revolutions, while if the engine then fails to go into operation, a second short heating of the coil will give another number of turns, and so on. A safety valve set at 500 lb. protects the device from excessive pressure.

Progress on the Baltimore Sewerage Works.

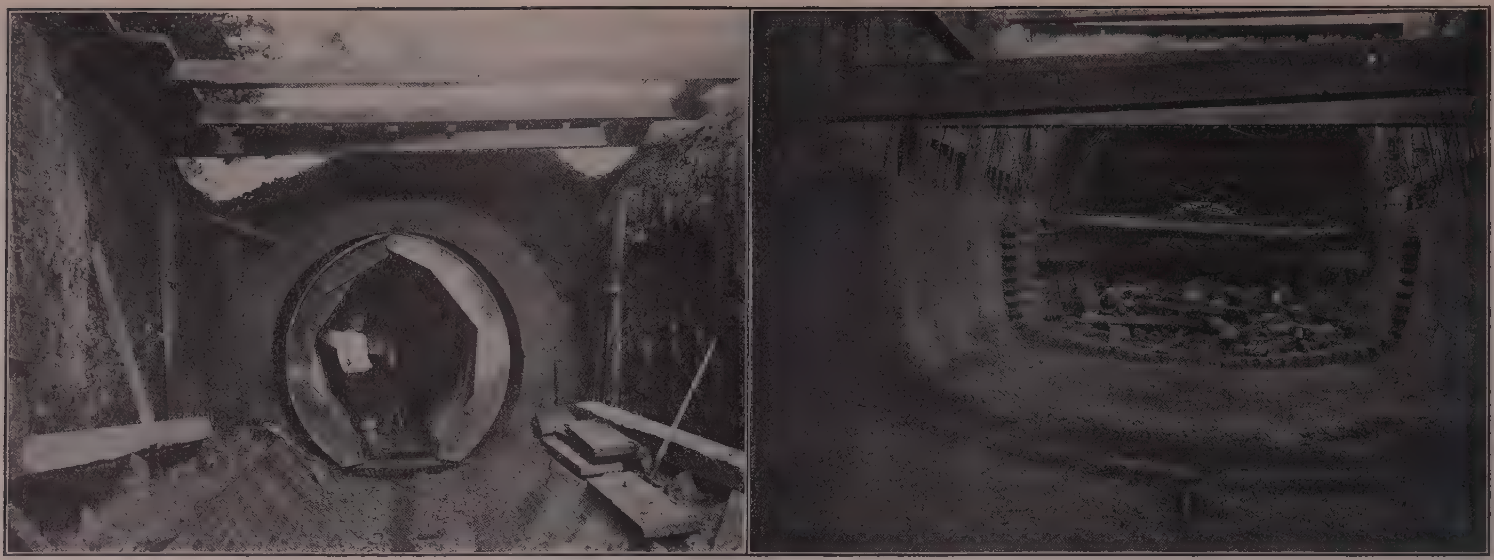
Work on the sewerage system of Baltimore, Md., to which many references have been made in this journal, is progressing with considerable rapidity, according to reports made by Mr. Calvin W. Hendrick, chief engineer of the Sewerage Commission, from which some of the following notes have been taken. These works when completed will give to Baltimore complete storm water and sanitary sewer systems capable of serving a population of 1,000,000, and a disposal plant capable of handling the sewage of the present population of 555,000, with facilities for ultimate enlargement to serve a population of 1,000,000.



Underground Pipes and Conduits, Gay and Lombard Streets, Baltimore.

The disposal plant, on which work of clearing and grading has begun, will be designed in accordance with the recommendations of the Board of Advisory Engineers, consisting of Messrs, Rudolph Hering, Samuel M. Gray and Frederic P. Stearns. In its report, which was published in the issues of The Engineering Record of July 28 and Aug. 4, 1907, this board recommended a disposal plant in which the sewage should be treated: 1, in a series of septic tanks in which the period of detention should be 6 to 8 hours; 2, in sprinkling filters composed of beds of broken stone about 9 ft. deep; 3, in settling basins where it should remain about 3 hours; 4, and finally, in artificial sand filters. The removal of bacteria by the first three processes is in the neighborhood of 95 per cent. of the total number present. The final process is also suggested because the legislative act under which these works are being built provides for the "highest practicable degree of purity" for the effluent; this requirement is designed to protect the oyster beds in the waters with which the effluent of the plant will eventually mingle.

Before designing so large a plant it was thought best, upon the advice of the chief engineer, to make a thorough study of the characteristics of the sewage to be treated, and accordingly a testing station was designed and built at a point that seemed to be favorable as regards the topography of the site and surrounding territory and where a flow of sewage of 50,000 gal. per day could be brought to the plant. This testing station, which was described in detail in The Engineering Record of Nov. 17, 1906, comprises a 30 x 10 x 8-ft. septic tank; two sprinkling filters, each 27 ft. in diameter with six radial division walls forming six beds of varying depths of hard crushed stone; twelve settling basins, each 4 ft. square and 3 ft. 7 in. to 4 ft. 6 in. deep; and a fully equipped laboratory building, 31 x 64 ft. Sewage is led to the station through an 18-in. sewer and the effluent is discharged into Gwynn's Run nearby. A general view of the testing station, which was built during the winter of 1906, is shown in an accompanying illustration. The results seem to strongly indicate that it will not be necessary to treat the sewage by sand filtration. This will be finally decided on later. The disposal plant is being so constructed that no delay will be caused by the work at the testing station.



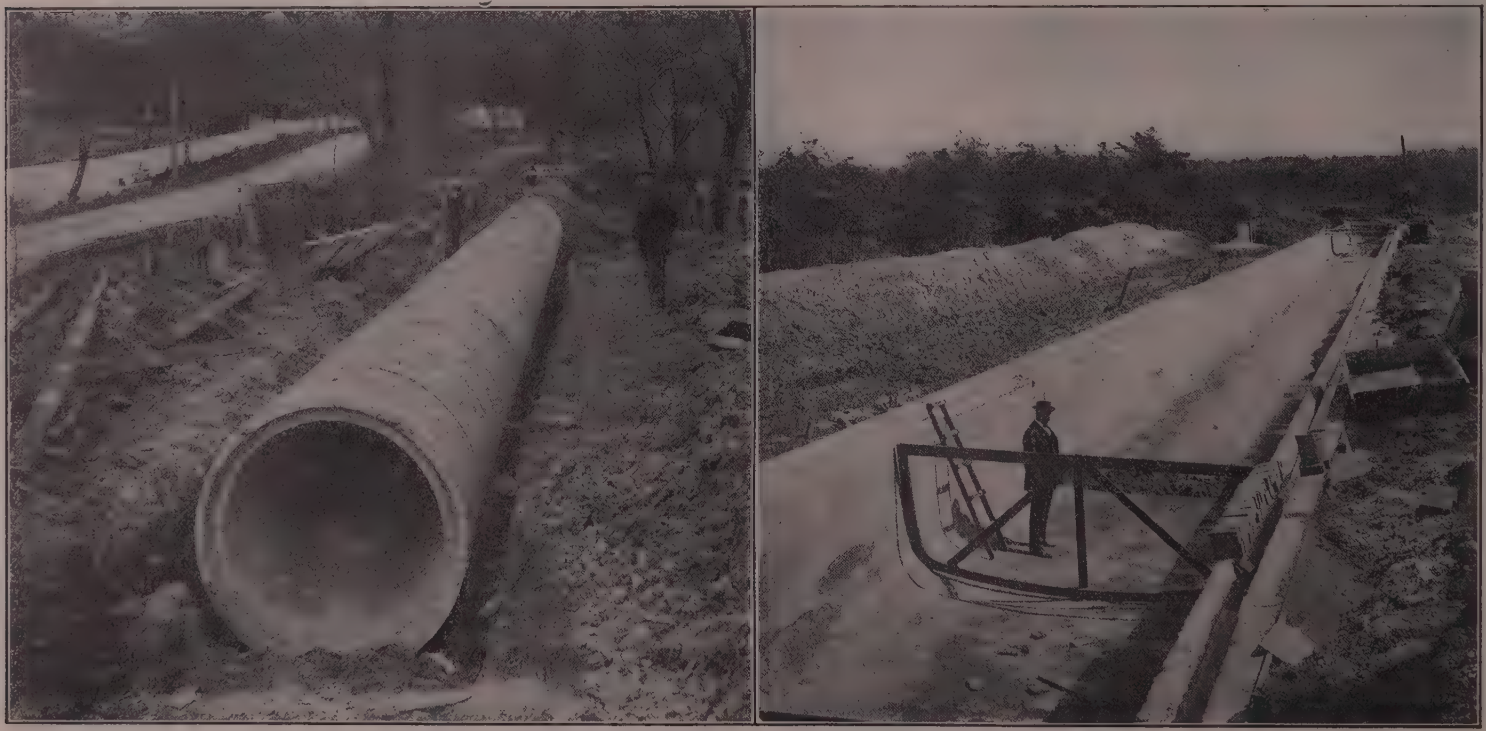
Collapsible Centers for 96-Inch Concrete Drain and Invert of Outfall Sewer, Baltimore.

In addition to the studies undertaken at the testing station, investigations have also been made or are in progress covering a great variety of subjects bearing on the design and construction of the disposal plant and sewers. These investigations include surveys and wash borings to determine favorable locations for the intercepting and outfall sewers and the disposal plant; analyses of city water and the waters of Patapsco River, Chesapeake Bay and other bodies of water; a study of existing drains and sewers and all other pipes and like obstructions above and below the street surfaces; a complete detailed survey of the city; investigations of population, water consumption, ground water, available materials and prices, lands and right-of-way, and trade wastes.

The Advisory Board of Engineers had suggested filtration through natural sand beds near the city as a possible alternative for filtration through artificial filters. The investigations made in 1906 included, therefore, tests of the sandy soil in Anne Arundel country within a reasonable distance of the city. Tests and analyses were made of a great many samples to determine the rates at which these soils would filter water, the loss of head, and the amount of moisture retained by capillary attraction after different periods of draining. Mechanical analyses of the soil in question indicated that the areas from which the samples were taken would serve as a natural filter with little to be desired. But further tests, made along the same lines as the soil tests incidental to the design of the Bohio dam, indicated that the percentage of dust and clayey material in these soils, which ranges from about 6 to 19 per cent., renders them entirely unfit for filter material.

In making the mechanical tests in the usual manner by putting in the whole sample and shaking it through the nested series of screens with 150 turns of the shaker, the finer particles clung very tightly to the larger ones and the apparent percentages of clay were low. Tests were also made by putting a full sample on the finest screen alone and giving the shaker 100 turns; then what remained on the finest screen was transferred to the next finer and this was given 100 turns. This was continued till the screen with 80 meshes per inch was passed when the material retained on this screen was placed on the coarsest screen, all the screens were nested, and the whole set was given 150 turns of the shaker. This method produced results in striking contrast with the ordinary method, the amount of dust taken out by the new method being several times as much as was discovered by the old method. The results by the new method were checked very closely by determinations by elutriation.

During 1906 sanitary sewers were laid out covering all developed parts of the city and having a total length of about 400 miles with about 420 additional miles of house connections. A storm water drainage system covering the entire city, with 160 miles of drains, 4,500 inlets and 23 miles of connections from inlets to drains, has also been designed. The total length of sewers, drains and connections will be over 1,000 miles. Up to the last of December, 1907, 93,761 lin. ft. or 17¾ miles of sanitary sewers, storm water drains and connections had been completed; 305 manholes had been built and 181 inlets had been installed. The amount of work completed or under contract in December, 1907, was divided as follows: Storm-water drains, $527,666.82; sanitary works, $2,791,511.51. The latter amount is distributed as follows: Sanitary sewers, $1,850,075.92; disposal works, $153,423.50; pumps, $450,000; land, $338,012.79. Thirty-five acres have been cleared at the site of the disposal plant;

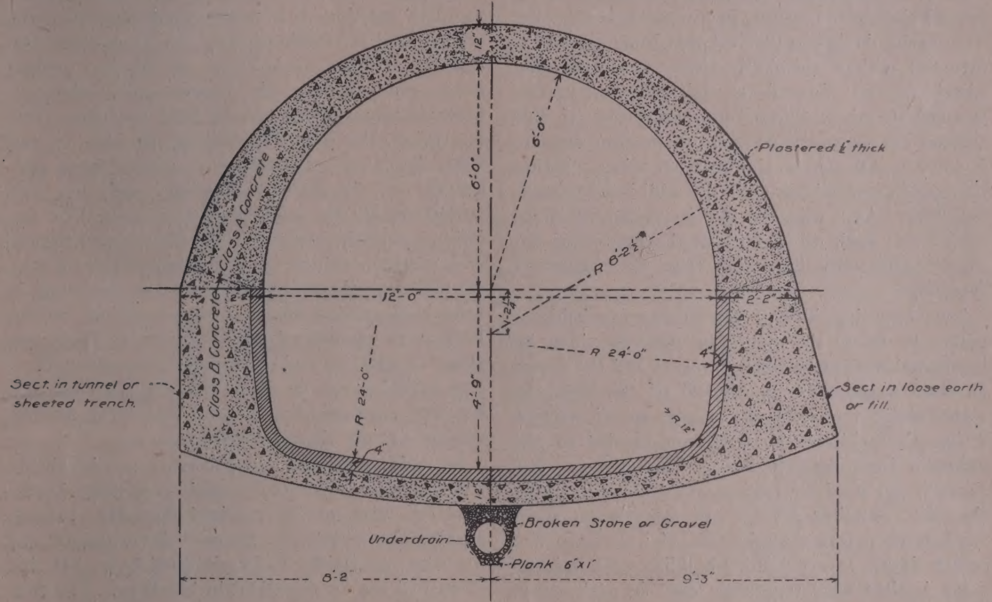


Views Showing a 46-Inch Reinforced Concrete Pipe Drain and Walls and Invert of Outfall Sewer, Baltimore.

37,000 cu. yd. of rolled embankment have been placed and 65,000 cu. yd. of earth have been removed.

The main outfall sewer from the disposal plant is 5.75 miles long. Part of this distance the section is 10 ft. 9 in. high and 12 ft. wide and the rest of the way it is 11 ft. high and 12 ft. 3 in. high. Both sizes are of the form shown in an accompanying illustration. It is built of concrete with a brick invert lining and reinforced at railway crossings. The first contract for storm-water drains is just about completed. Some of the construction methods used on this contract were described in The Engineering Record of April 6, 1907, and accompanying illustrations show other features of the work.

A considerable area in the city lies below El.80 and the sewage of this district will have to be pumped, the total lift, including friction in the pipes, being 72 ft. There will be three 27,500,000-gal. triple-expansion, vertical, crank-and-fly-wheel, condensing pumping engines with room for a further installation of two more. The first three pumps are now under construction by the Bethlehem Steel Co. One of the three will always be held in reserve. Steam will be supplied by three water-tube boilers, each of sufficient capacity to run one engine and all auxiliaries. The pumping plant will be housed in an attractive building which will soon be put under contract.



Cross Section of Outfall Sewer, Baltimore.

The storm-water system involves some very heavy work, including the enclosing of Jones' Falls, a stream which crosses the city draining an area of about 27 acres. The flow of this stream during heavy rains is estimated at 10,000 cu. ft. per second; it has a fall of 150 ft. in four miles. This stream is to be improved for 8,850 lin. ft. by the construction of an enclosing conduit with one, two or three barrels, depending on local conditions. The roof of this conduit will probably carry a driveway for heavy traffic.

The congestion of public service pipes in some of the business streets has at times made the placing of the new pipes very difficult. An accompanying illustration shows the arrangement of pipes at the intersection of Gay and Lombard Sts., where a new storm-water drain was carried across. The elevation of the street surface at this point was only 8½ ft. above mean low water, but the pipes were adjusted satisfactorily at a low cost.

AN ICE-BREAKING CAR FERRY for service during the winter is being built at Toronto for operation on the St. Lawrence River between Prescott, Canada, and Ogdensburg, N. Y.

Reinforced Concrete from the Contractor's Standpoint.

A paper read before the National Cement Users' Association by Mr. H. H. Fox, of the Turner Construction Co., New York.

The general problem before the contractor in reinforced concrete is to make the best possible reinforced concrete at the least possible cost. The first part of this discussion will deal with methods to be followed and precautions to be observed in order to attain excellence of workmanship; the second part, with methods to be followed in order to attain this excellence cheaply.

To make the best possible reinforced concrete it is necessary:

1. That the forms should be strongly built, smoothly finished, and as nearly as possible watertight; and should be left in place until the concrete is self-supporting.

2. That the reinforcement should be designed to relieve the concrete of all stresses which concrete cannot safely withstand, and to be amply protected from fire and weather by concrete on all sides; that the reinforcement should be so securely fixed in place before concreting that the concreting will not disturb it.

3. That the concrete should be mixed and placed in such a way that the final product will be homogeneous and without voids.

First.—Forms should be built of matched and dressed lumber and should be greased to make them part easily from the concrete. Their construction will be described in some detail in the second half of this paper. The length of time which should be allowed to elapse before removing forms depends upon two factors, the weather and the load to which the member in question will be subjected upon removal of the forms. The fact that the concrete sets more rapidly the warmer the weather needs no elaboration. It is, however, never out of place to utter a warning against taking risks with concrete in cold weather. I suggest that very valuable information might be obtained from compressive tests on a series of concrete blocks, No. 1 being kept at a temperature of 30° for one month after making, and being tested; No. 2 at 35°; No. 3 at 40°, etc. Scratching concrete with a knife gives one a rough idea of its strength, providing one scratches often enough to become thoroughly familiar with the behavior of concrete under the knife. With regard to the second factor influencing the time which should elapse before removing forms, it may be said in general that the nearer the load to be sustained approaches the load for which the member was designed, the longer the forms must remain. Thus, the forms for an over-hanging cornice should remain in place longer than the forms for almost any other member, because the dead weight of the cornice is a very large percentage of the total weight which it is designed to carry. By similar reasoning, roof forms should remain longer than floor forms; floor forms longer than column forms; column forms in the top story of a building longer than column forms in a lower story; and column forms in general longer than footing forms.

It is very important that forms should be so designed that the column forms may be removed without in any way disturbing the supports of the beams and girders bearing on these columns. In this way a defect in a column may be detected and remedied before any load is brought to bear upon the column. In removing beam and girder forms, the posts should be removed from only one beam or girder at a time, and as soon as the form for this beam or girder is removed, the posts should be immediately replaced. By this procedure, danger of failure of concrete through poor workmanship is much diminished, as a defective member is supported by the members on either side of it until the defect may be remedied. The practice of removing all the posts under a floor at the end of a given period—one, two, or three weeks—without pausing to remove the forms one at a time, examine the workmanship, and replace the posts, cannot be too strongly condemned; both because of the possibility of defective workmanship, and because the concrete floor, even if not defective, may not be strong enough to carry in addition to its own weight, the weight of the one or two floors which may, by the time the forms are removed, have been constructed above it.

There is less danger in taking down column forms when the concrete is thirty-six hours old, and floor forms when the concrete is five days old, if the posts of each member are removed separately, and as soon as possible replaced, than there is in knocking out all the posts under a large piece of floor in three weeks. Legislators who frame laws aiming at safety in concrete construction should bear this in mind.

It is of first importance that the foreman in charge of removing forms should be of a high order of intelligence, and a man who can be relied upon to obey orders literally, for the reason that a mistake on his part is more likely to cause damage to life and property than a mistake on the part of any other foreman.

Second.—Reinforcement should be designed to take all tensile stresses which occur in a reinforced concrete structure. Whether the reinforcement shall carry shearing or compressive stresses depends upon the conditions in each particular case.

Tensile stresses occur horizontally in the bottom of beams, and, in the case of continuous beams, in the top of the beams over their supports. They occur diagonally in every part of a beam except the top and bottom. The horizontal tensile stresses are taken by horizontal bars. The diagonal tensile stresses are best taken—as most authorities are now agreed—by diagonal bars. As the horizontal tension is less at the end of a beam than in the center, it is obvious that if there are two or more bars in a beam, one of the bars which takes the horizontal stress at the middle of the beam may be deflected to take the diagonal tension near the ends of the beam, and in the case of continuous beams, the horizontal tension over the supports. Thus are developed the familiar bent bars now in common use.

Shearing stresses occur chiefly near the supports of beams. The vertical shear is generally taken partly by the concrete and partly by the tension bars which run over the support. Horizontal shear is taken partly by the concrete, partly by the diagonal tension bars, and partly by stirrups.

Compressive stresses occur chiefly in the tops of beams and in columns. Compression in beams is almost always taken by the concrete alone. Compression in columns is taken partly by the concrete, partly by vertical steel bars. Vertical compression in columns induces a horizontal tension or bursting stress. Concrete is so weak in tension that a concrete column without reinforcement usually fails in tension, either by bursting or by buckling. The tendency to buckle is best resisted by vertical steel bars; the tendency to burst, by steel hoops or a steel spiral near the surface of the column.

One method of holding steel in place in a typical beam containing three tension bars is by stirrups that touch the forms only at two points and are, therefore, well protected against fire. The stirrup should not be relied upon to support the tension bars in place, but hangers should be used. As these hangers are of no further value after the concrete is in place, the fact that they are supported directly on the forms, and are thus not fireproofed is of no importance. The middle portion of the tension bars in beams and girders is thus held in place by hangers; the ends are held in place by being laced with wire to one another and to the vertical reinforcement in the columns. The bars in the floor slab are supported off the forms as follows: In order to obtain continuous action over beams every alternate tension bar in the floor slab is sprung up where it crosses a beam, being supported at the edge of each beam by a short piece of band iron about 1½ in. narrower than the thickness of the floor slab, and bent to an angle of about 60 deg., so that it will stand on edge by itself. In the middle of each span a bar runs at right angles to the tension bars, on top of the tension bars, and is held at any desired distance above the floor by staples into the floor cover and by the lifting tendency of the tension bars which are sprung up over the beams. The other tension bars are then raised from the floor by lacing them with wire to this central bar.

To insure fireproofing in columns, four sticks are used in tamping the concrete columns, and these sticks are run down one on each side of the column between the hoop or spiral reinforcement and the form, thus insuring an amount of fireproofing equal at least to the thickness of the stick. The vertical reinforcement is placed inside the hoop or spiral reinforcement.

Commercial methods of bending steel to the shapes above mentioned will be considered in the second half of this paper.

Third.—How to mix concrete well, by hand or machine, needs no discussion. How to place it well is another matter. In the case of floors the trick is simple. Concrete should not, unless it is absolutely necessary, be dumped from a wheelbarrow directly against the form, but should be dumped on the soft concrete already in place. The mortar, flowing more freely than the stone, keeps always ahead of the mass, and stone falling in this mortar find a perfect bed; whereas if a barrowful of concrete is dumped into a dry beam the stone may become jammed between the forms and the steel and form a pocket into which the mortar will not enter.

A few years ago I visited a very large concrete job on which the old-fashioned specifications were in force—that concrete must be placed in thin layers. Nobody on the job seemed to know the trick of placing concrete properly; and consequently the contractor, in order to obtain smooth workmanship, was placing an inch or two of clear mortar in the bottom of all beams and girders, before filling them with concrete. The expense entailed by this may be imagined.

The place to dump the first barrowful of concrete when starting a piece of floor is either on the floor slab or in a column. As long as the mass is kept moving it will be homogeneous, but if it is allowed to set in a diagonal shape two evil results will follow: First, the cement and water, the most fluid part of the mass, will flow forward leaving behind a layer consisting chiefly of sand, with which the concrete, subsequently placed, will not mix, and which has very little value as fireproofing; second, the scum which rises to the surface of wet concrete, containing as it does the finest dust present in the sand and stone, sets with a very smooth, glassy surface to which fresh concrete will not adhere. This joint, therefore, if work is stopped on it long enough to allow the scum to harden, will be very weak in shear and tension.

In concreting columns it is necessary to proceed slowly at the bottom of the column and to tamp the first foot with great care. After the mortar flushes to the surface over the entire section of the column, there is little danger of voids being left in the part of the column above the first foot if a sufficiently wet mixture is used. Walls should be similarly handled.

Economy in Handling Materials.—The exterior column is usually made square for architectural reasons. The interior column is octagonal, partly for architectural reasons, partly to save concrete. This saving is due to the fact that in a column reinforced with a spiral, the concrete outside the spiral is not figured as adding compressive strength to the column, and, therefore, if this column is square, the concrete in its four corners is wasted. Of course, the question arises whether the concrete saved pays for the additional carpenter work. As a rule, the two items almost counter-balance each other, so that the matter of appearance is more important than the matter of economy.

Two opposite sides of the column are held together by bolts; the other two opposite sides, by hardwood wedges between the bolts and the forms as close as possible to the end of the bolt. In some cases, the sides are made up of narrow strips, to facilitate the reduction in size of the columns from floor to floor. In warm weather there is no need of having more column forms than one complete set for one story, even when work is progressing at the rate of a story in five or six days. In a ten-story building each column form is then used ten times, once in each story. Each of these narrow strips represents the reduction in diameter of the column from one story to the next. It is, of course, much cheaper to have these strips ripped beforehand in the mill than to have a carpenter rip off a strip for each successive story. The outside and inside of the exterior column form are not made up of narrow strips for the reason that exterior columns are usually the same width from basement to roof. To reduce the section of an exterior column only the thickness is reduced.

In beam work the "girder bottom" is supported on the horizontal clamps of the column form, and the beam forms on the girder bottom. Thus all the forms of a floor may be erected before any posts are put in. At any time after the beams are in place the posts are put in and wedged up without any lateral bracing whatever. By this method time and labor are saved. If 2-in. lumber is used for beams, the beams must be at least 2 in. shallower than the girders, in order to allow the beam forms to be supported by the girder bottom.

A wedge-shaped piece in the form of a "key" is inserted to facilitate removal of forms. The flat cover or panel which supports the floor slab is better than the box-shaped type, for the reason that any slight errors in line are taken up at the junction between cover and beam side, and a slight variation in this dimension is not conspicuous.

In removing forms, the column forms are first removed. As has been said, the details about the tops of columns forms should be so designed that they may be removed without in any way disturbing the beam and girder forms. Next, the posts are taken from under the girder. The girder bottom then drops, and the posts are immediately replaced. The nails are drawn from the key, which is nailed only to the girder side; the key is knocked out, the posts are taken from under the beam, the so-called "spreaders" are knocked from under the cover, and the beam form comes down in one piece. The girder sides, which are beveled at the ends, come out easily as does also the cover, which is beveled on all four edges.

A circular saw will effect economy in a building of moderate size, especially if the same engine or motor may be used to run the saw and other machines, such as a boring machine, a steel hoist, a grindstone, or a shear.

In warm weather, with a complete set of forms for one story, a speed of construction of one story in eight or nine working days may be attained. With one complete set of column forms and a set and a half of floor forms, a speed of a story a week may be attained. The size of the building in plan makes very little difference.

In the discussion of methods of handling steel, the first question is, to what extent shall machinery be used in bending bars? At the present day there is, so far as I know, no machine which bends tension bars for beams and girders as economically as they can be bent by hand. For one thing, the cost of handling the bars to and from the place of bending is a very large percentage of the cost of bending, and this cost would remain the same in either case. The decisive reason is, however, that the variety of possible shapes of bent bars is infinite; the number of different shapes required in one building is very large, and a machine, to be efficient, would have to be capable of rapid adjustment from one shape to another, and consequently complicated.

A machine can be made to bend stirrups and hangers economically, as they are light and of smaller variety than tension bars.

In making spirals two processes are involved: First, bending the steel, which is usually in the form of wire, to the required diameter; second, spacing the coils to the required pitch, and fastening them so rigidly to longitudinal bars that this pitch will not be disturbed in handling. The first process is accomplished more economically by machine, the second usually by hand.

A simple cast-iron block may be used for bending beam and girder bars. The block is attached rigidly in a horizontal position to a bench, the bar is dropped in a slot in the block, a piece of extra heavy pipe is slipped over the end of the bar, and two or three men bend it to the required angle. This bending block may be made of an iron plate with two angles riveted to it back to back to form the slot. Stirrups when bent by hand are bent on such a plate, the angles, of course, being small and only far enough apart to admit a bar of the size used for stirrups. A plate for bending stirrups may be made small enough to slip in the pocket.

Spirals are made up on a simple wooden reel, the requisite of this reel being that it should be rigid, adjustable for different diameters, and collapsible to allow the finished spiral to be easily slipped off.

The question whether power other than hand-power should be used to hoist the reinforcement to the floor where it is to be used depends upon the height of the building, the quantity of steel on each floor, the rate of progress, and the prevailing rate of engineers' wages. In New York City the wages of an engineer for one day will pay for a good deal of hoisting by hand; and it may be roughly stated that when the rate of hoisting is less than one foot-ton per minute, nothing is gained by installing special machinery for hoisting steel. It is of course necessary to have steel on a floor before concrete; therefore, the necessity of having a derrick light enough to be attached to the forms before they are filled is apparent. The strain of the fall-rope on the derrick pulls the column to which it is attached out of plumb less than an inch, and this displacement is easily recovered with a guy-rope and turn-buckle before concreting.

The question whether or not a charging hopper shall be used depends on several things. Unless it is possible to set the mixer several feet lower than the storage of sand and stone, some kind of hoist must be arranged to fill the hopper. This means additional machinery and generally the wages of an additional engineer. In New York City one of the obstacles to setting a mixer much lower than the storage piles is tidewater. Basement floors in New York are often laid as near tide level as possible; during the construction of a building the basement is used for storage of sand and stone and in order to set the mixer much lower than the basement floor an expensive waterproof pit must be constructed. A charging hopper, of course, makes it possible to charge the mixer more rapidly; but the fact should be borne in mind that no time is saved by charging the mixer more rapidly than the concrete can be taken away, up on the floor. The mixer should be set so low that the wheelbarrows run on a level or slightly down-grade in feeding the mixer.

In many cases the mixer is driven from the shaft of the hoist, and this shaft, from the motor.

The question how large a mixer to install depends upon the rate at which concrete is to be used. Without a charging hopper, an ordinary mixing plant will turn out easily forty batches per hour, and may be made to turn out sixty batches if the hoist is designed to take it away as fast as that. In laying out a schedule for concreting, attention should be given to the fact that speed makes for economy, for the reason that there are several special men in a concrete gang whose wages remain the same regardless of the amount of concrete placed. These are an engineer, a foreman, and at least three laborers, viz., one throwing water into the mixer, one dumping the mixer and one loading the wheelbarrows up on the floor. The sum of their wages at New York rates is $16.60 per day. If 80 cu. yd. are mixed in a day these men add to the cost of mixing about 20 cents per yard; if 160 cu. yd. are mixed they add only 10 cents per yard.

With regard to plant in general it may be said that many contractors make the mistake of installing more machinery than is warranted by the quantity of material to be handled by this machinery. For example, on a piece of concrete work containing about 1,500 cu. yd. of concrete, which I once visited, $10,000 had been spent on plant before a yard of concrete was mixed. At least $6,000 of that was wasted; for, although the unit costs may have been made less than they would have been if more primitive methods had been employed, the total costs, including the cost of installation, were much greater. The machinery did not have enough to do to pay for itself. To determine correctly the kind and quantity of machinery to use, a contractor must have good judgment and a thorough knowledge of costs.

THE LARGEST YEARLY LUMBER CUT in the United States was that of 1907, the amount being 37,550,736,000 ft. B. M., valued at $621,151,388. All other timber products bring the total to 40 billion feet, according to a circular from the U. S. Forest Service. Since 1899 the cut of white pine has dropped 40 per cent., and oak, 36 per cent., while Douglas fir has increased 186 per cent. Yellow pine now leads, with Douglas fir second. Washington, though sixth in lumber production eight years ago, now leads all the states, while Wisconsin has dropped from first to third. The average increase in the price of lumber since 1899 has been 49 per cent.

Book Notes.

The annual number of the "Solar Ephemeris" for 1908 has been issued by the Keuffel & Esser Co., Adams and Third Sts., Hoboken, N. J. This little pocket-book contains all the tables and directions necessary for determining the meridian, ascertaining the latitude, and making observations for time at any point by means of the company's solar attachment to the engineer's transit.

An elementary book on "Highway Construction" has been written by Messrs. A. T. Byrne and A. E. Phillips which not only outlines highway construction, but also describes the elements of city pavements. It is the kind of a book which will be found useful by city officials without any technical training and by the general reader who wishes to obtain some knowledge of the general methods followed in constructing roads and streets. (Chicago, American School of Correspondence, $1.00.)

Four excellent pamphlets have been prepared by Mr. Arthur R. Hirst, highway engineer of the Wisconsin Geological and Natural History Survey, which has its offices at Madison. The first is a description of the methods of building earth roads, the second is an explanation of the road drag and the methods of using it, the third describes the construction of stone and gravel roads, and the fourth explains the construction of culverts and short bridges. In each of these pamphlets, stress is laid on the importance of building well whatever is undertaken, whether it is an earth road or a reinforced concrete bridge. The information is clearly stated and reliable, the illustrations are excellent and really show something that is worth knowing, and the tables of cost seem to be fairly good averages, which is all they are claimed to be. Each of the pamphlets contains an extract from a letter from a farmer in Taylor County, in which this statement is made: "I emigrated from Germany, made a farm here, and lived on this farm 23½ years. I have seen in these years hundreds of thousands of dollars of taxpayers' money expended on the roads in town and county, but after all our roads are still as bad as ever. Not the scarcity of money, but the system is to blame for this state of affairs." These little pamphlets should do much to show in what respects the systems referred to are wrong.

Prof. H. H. Norris, of Cornell University, has written a book entitled "An Introduction to the Study of Electrical Engineering" that is a most encouraging addition to elementary textbooks. It is no secret that at the present time the instruction in science in high schools and academies is below the high level attained many years ago by instruction in the classics. As a result the mental training received by the pupils in these science courses, who elect them in place of Greek and Latin, is more or less superficial. It is an undoubted fact that the sloppy-minded pupil can make a fair recitation in science much more easily than he can in the classics, and it is not surprising, therefore, that considerable attention is now being paid to devising methods of remedying this condition. The book by Professor Norris ought to do a good deal to help raise the character of instruction in elementary electricity. He has broken away entirely from the childish generalities of the familiar type of schoolbook and has developed a real elementary course in electricity from a study of apparatus familiar to all. With the exception of one or two places there is nothing in the book which an intelligent young man cannot thoroughly understand before he enters a technical school. Moreover, any youth who does not find this method of studying electricity much more interesting than a parrot-like memorizing of the thin generalities of Arnott and Deschanel is wasting his time in taking science courses. "The plan of this introductory work," the author explains, "is to take the every-day experience of the student as the basis of a general survey of electrical applications. Everybody rides on electric cars, uses telephones and electric lights, and in other ways comes into more or less intimate contact with electrical phenomena. By combining with this experience the lessons taught by scientific research, a clear conception of electric laws should result." The book opens with an interesting sketch of the development of electrical engineering. This is followed by an explanation of the fundamental electric and magnetic quantities, and this is succeeded in turn by a chapter on the materials of electrical engineering. Then follow explanations of the phenomena of electric and magnetic circuits, and two chapters on the construction and operation of electric generators. The chapter on transformers and application is a particularly good explanation of these important parts of a modern system of power distribution. There is an unusually comprehensive chapter on the construction and operation of power stations, which is open to but one criticism, that the descriptions refer mainly to very large stations, while it might be better for the average student to describe plants of moderate capacity. The tenth chapter is a description of electric motors and their application, and the eleventh chapter takes up electric lighting and heating. In both of these, the descriptions relate to apparatus which is standard at the present time and can be seen by anyone who will take the trouble to visit a car barn, machine shop or electric light station. A chapter on electric measurements describes the methods and instruments which are actually in use in commercial work, and does not take up the laboratory apparatus and the old instruments employed for class work some twenty years ago. The closing chapter is a description of the telegraph, telephone and other instruments for transmitting messages. There is an appendix on the fields of application of alternating and continuous current which is likely to be of use to those taking up the subject of electricity for the first time. The volume is well illustrated and deserves a very careful study by instructors in high schools and academies who wish to make their courses of real value instead of a means of smearing the youthful intellect with a skim coat of worthless generalities. (New York, John Wiley & Sons, $2.50.)

Letters to the Editor.

EXPERIENCE WITH CONCRETE IN FORTIFICATIONS.

SIR: I note in your issue of to-day under the above title, a review of a paper on this subject by Major E. Winslow, Corps of Engineers, U. S. A., recently published in the "Journal of the U. S. Artillery." As I have had an experience for a period of 20 years with natural cement concrete in use as a foundation for pavements and had an opportunity in 1898 to study this material as used in gun emplacements at Fort Totten, L. I., when an attempt was made under my direction to waterproof the same with asphaltic concrete, I may be able to add something in the way of an explanation as to why such concrete is so permeable to water as compared to that made with Portland cement.

This is due primarily to the fact that the setting of natural cement takes place in quite a different way from that of Portland cement. The latter is an extremely dense and basic material which, on mixing with water, liberates, very slowly, a very considerable amount of free lime, which forms a supersaturated solution with the water present and afterwards crystallizes out and binds together the residual cement into an extremely dense and non-porous mass. Natural cement contains no lime in a condition to act in the same manner. As a result, the lime mortar is porous for this reason, and because of the lack of density of the cement itself.

In the second place, the early natural cement concretes were laid much too dry, as at that time the desirability of laying a very wet concrete was not understood. Had Portland cement been used in the same manner, the result would be a much more porous and less dense mass than is obtained to-day. The advantages of placing concrete very wet are so well known at the present time that its application in this form is universal, and is nowhere better exemplified than in the construction of the new concrete bridge over the Wissahickon in Philadelphia, where the material is placed in the forms in such a wet condition that little tamping is required, and large stones can be and are readily embedded in it by hand.

Portland cement concrete is to-day rendered very waterproof by the addition of several very satisfactory materials which have been prepared for the purpose. There should, therefore, be no great difficulty in the preparation of waterproof concrete in the construction of fortifications.

As far as darkening the surface is concerned, it is rather surprising to note that lampblack not soluble in water may be reduced to the form of a solution by using wood alcohol or other cheap solvents, as it has not heretofore been observed that carbon was soluble in such solvents. In regard to the action of oil coatings upon Portland cement concrete, it is well understood that the crumbling of cement only takes place when the oil which is applied to it is one which can liberate free organic acids, that is to say, an animal or vegetable oil, and these, of course, should be avoided. A mineral oil will not act upon Portland cement at all unless it contains some residual acid used in the preparation, and this is very unusual.

A coating of any asphaltic compound will render Portland cement waterproof, but such a paint possesses the objection that, when exposed to sunlight, it deteriorates rapidly. This, however, can be prevented by adding to it a proper percentage of graphite, which prevents the actinic action of the sun upon the bitumen. It was at one time believed that an asphaltic concrete used as a finishing course for the hydraulic cement concrete would not only prevent water from reaching the latter, but would withstand the blast of guns very satisfactorily, owing to its elasticity, but experience has shown that this material cracks when used in this way. Such a concrete is satisfactory as a roadway when subjected to traffic which will keep the surface closed up, but it possesses the unfortunate property of contracting in cold weather longitudinally and expanding under the sun, in the line of least resistance, vertically. This results in the cracks which made its use as employed at Willett's Point a failure. It is possible, with our more extended experience with this material, that it can be even now adapted for the purpose by making the cement of which it is composed somewhat softer. It possesses the very great disadvantage, however, that it is a comparatively expensive material.

Yours very truly,
Clifford Richardson.

New York, Jan. 25.

The Cameron Septic Patent.

Sir: In view of the fact of the decision of the United States Circuit Court of Appeals in the matter of the Cameron Septic Tank process, I beg to suggest to the profession and others interested that a committee of engineers be delegated to take the matter up with the Cameron Septic Tank Co., with a view of coming to some amicable adjustment, whereby an engineer or engineering firm may acquire the right to the use of this process for his or its clients, so as to place the profession on an equal basis in the matter of the cost of the aforesaid rights. It could be placed upon a per capita basis, inasmuch as the cubical contents of a septic tank for a given service varies considerably, for engineers differ much in respect to their size.

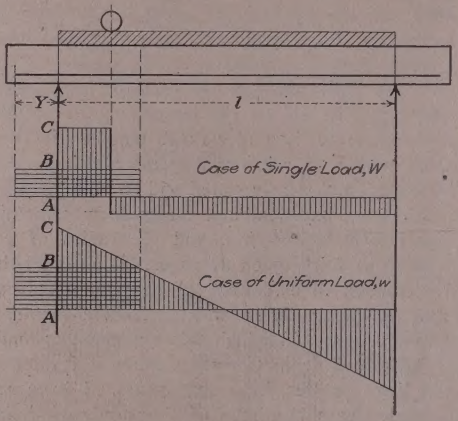
The Cameron Co. would surely act in a highly professional spirit in the matter, and would probably be willing to act in an engineering capacity on similar terms with other engineers. The adjustment of claims on plants already installed could be made upon some acceptable basis.

I submit the foregoing with the idea of eliminating future litigation and clearing up the situation, in order that the septic process may be advocated by engineers and included in their designs on unquestionable lines, as best serving their clients' interest as well as their own.

New York, Feb. 1. Augustus C. Hepp.

Size of Reinforcement Bars.

Sir: The formulæ for the maximum size of bars in reinforced concrete beams, developed by Mr. Wm. P. Creager in The Engineering Record of Jan. 25, are of unusual value and interest on account of their simplicity. Before applying them to actual practice, however, some slight changes seem desirable, as their demonstration involves an assumption which is "on the side of danger."



In a non-continuous beam, the shear, or rate at which the bending stress is actually applied to the beam, is represented by the ordinates of the vertically hatched portions of the accompanying diagram. Mr. Creager in his demonstration tacitly assumes that all the stress to the left of a certain section (A) of maximum adhesive stress is distributed uniformly to the tension portion of the beam, or as represented by the ordinates of the horizontally hatched rectangles. While it is probable that the elastic deflection of the materials will slightly reduce the maximum shear represented by AC, it is very improbable that it can reduce it to AB, as is assumed by Mr. Creager, especially in the case of large values of y. To be certain, therefore, of being on the side of safety, it is necessary to assume a disposition of stress as shown by the vertically hatched areas. The truth will lie somewhere between these two extreme assumptions.

To find a formula for the maximum thickness of bar under the latter assumption, take the case of a uniformly loaded beam with square reinforcing bars. Use the same notation as before and let h be twice the distance from the neutral axis to the center of the tension bar. Then at the center of the beam, $Wl^2/8h = Sd^2$, and at the end, considering the end shear, $\frac{1}{2} wl$, to be uniform for a distance δx, $F = Wl\delta x/2h(4d\delta x)$. Combining, there is found the required formula, $d = Fl/S$. The same result is found by using round bars or by moving a single concentrated load across the beam.

It will be seen that this formula calls for a maximum diameter of bar just half that obtained by Mr. Creager for the special case of $F = l/8$. The above formula should be used where it is desired to be absolutely certain that the beam will not fail by shearing of the metal on the concrete. Mr. Creager's formula gives beams which will certainly fail by the shearing of the metal on the concrete before the metal receives its ultimate stress. The size of bar which will make both kinds of failures occur at once is what is desired in practice. Probably as close an approximation to the truth as can be obtained is to take the mean of the diameters found by the two formulas. For all ordinary beams, results as accurate as the method warrants will be given by the formula, $d = 1.5\,Fl/S$.

Very truly yours,
H. A. Thomas.

New York, Jan. 27.

Conservation of Water Power.

Sir: I enclose herewith a copy of the resolutions on forest preservation adopted by the Board of Directors of the American Institute of Electrical Engineers, Jan. 10, 1908. It is my personal opinion and that of other members of the Committee on Forest Preservation of the Institute, that these resolutions apply with especial emphasis to the Appalachian watersheds. I would ask your careful consideration of the report of the Secretary of Agriculture on the "Southern Appalachian and White Mountain Watersheds" (Senate Doc. 91, 60th Congress, 1st Session), which is as interesting as it is convincing. That it is conservative, I know from personal observations in New Hampshire during the last fifteen years. It also shows conclusively that National Forests in these regions are as urgently required from the standpoint of timber supply as for the protection of waterpowers.

I believe strongly that the bill, H.R. 10457, providing for National Forests in the Appalachians deserves the active support of the engineering press and of engineers as individuals.

Very truly yours,
Charles H. Porter.

Boston, Jan. 28.

[The resolutions referred to by Professor Porter read as follows:

"Whereas, The American Institute of Electrical Engineers recognizes that water powers are of great and rapidly increasing importance to the community at large, and particularly to the engineering interests of the country; and,

"Whereas, The value of water powers is determined in great measure by regularity of flow of streams, which regularity is seriously impaired by the removal of forest cover at the headwaters with the resulting diminution in the natural storage capacity of the watersheds, this impairment frequently being permanent because of the impossibility of reforestation, owing to the destruction of essential elements of the soil by fire and its loss by erosion; therefore

"*Be It Resolved*, That it is the opinion of the American Institute of Electrical Engineers that the attention of the National and State Governments should be called to the importance of taking such immediate action as may be necessary to protect the headwaters of important streams from deforestation, and to secure through the introduction of scientific forestry and the elimination of forest fires the perpetuation of a timber supply; and further

"*Be It Resolved*, That the Committee on Forest Preservation be instructed to communicate these resolutions to all Members of Congress, and to the Governors of all the States."

It should also be added that, according to reports from Washington, Speaker Cannon has withdrawn his opposition to the bill, which has heretofore been the most serious obstacle to its passage.]